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SURGICAL DIAGNOSIS

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SURGICAL DIAGNOSIS

BY

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VOLUME I

WOUNDS AND THEIR DISEASES · DISEASES OF THE SOFT PARTS AND OF THE BONES · TUMORS · FRACTURES AND DISLOCATIONS · SYPHILIS THE X-RAYS · THE HEAD AND NECK · THORAX AND BREAST THE ABDOMEN IN GENERAL · THE PERITONEUM AND INJURIES OF SPECIAL ABDOMINAL ORGANS

WITH ONE COLORED PLATE AND TWO HUNDRED AND FIFTY-SEVEN ILLUSTRATIONS IN TEXT

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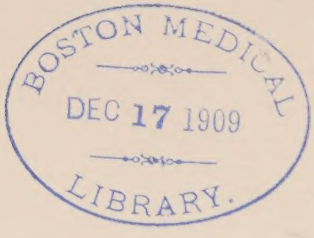

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TO

DOCTOR CHARLES McBURNEY

THE GREATEST SURGICAL DIAGNOSTICIAN
THE AUTHOR HAS EVER KNOWN
THIS WORK IS DEDICATED
AS A TOKEN OF HIGH ESTEEM AND IN
GRATEFUL REMEMBRANCE

PREFACE

In this work the author has attempted to treat the subject of "Surgical Diagnosis" upon fairly broad lines. It has seemed to him that the practical value of such a treatise would be increased if, in addition to a description of methods of examination and a relation of signs and symptoms, there were added some pathological data, as well as brief histories of illustrative cases. In carrying out this idea, however imperfectly, he hopes he may have succeeded in giving to the medical profession a book which shall be at once a help to those who desire to study the subject of surgical diagnosis, as well as a direct aid to the physician and surgeon in arriving at a correct diagnosis in the individual case. The work embodies to some extent the impressions gained during an experience extending over a period of nearly twenty-five years, spent in the surgical wards of three hospitals in the city of New York—namely, Bellevue, the Roosevelt, and the New York Hospital.

In preparing this work, the author has had constantly in mind the needs of the *practitioner of general medicine*, and it is to him especially, he believes, that this work will be found valuable.

The author desires to express his gratitude to the following gentlemen for permitting him to use illustrations from their publications: Dr. Francis S. Watson, of Boston; Dr. George Woolsey, Dr. Pearce Bailey, Dr. M. A. Starr, Dr. F. T. Brown, and Dr. Frank Hartley, of New York; Dr. Harvey Cushing and Dr. Howard Kelly, of Baltimore.

The following gentlemen have been kind enough to give to the author photographs of their own cases, or to permit him to use such, some of which are reproduced in the text: Dr. Charles L. Gibson, Dr. Ellsworth Eliot, Dr. Francis W. Murray, Dr. Lucius W. Hotchkiss, Dr. James C. Ayer, Dr. Benjamin S. Barringer (a number of original drawings of patients and specimens), Dr. Lewis A. Conner, Dr. Lewis A. Stimson, Dr. P. R. Bolton, Dr. William A. Downes, Dr. Eugene Pool, Dr. James N. Hitzrot.

The author wishes especially to express his thanks to Dr. Charles E. Farr. For the past five years Dr. Farr has taken photographs of nearly every case entering the New York Hospital which could be of use in this book, when it was practicable for him to do so. A small proportion only of these could be utilized for reproduction as illustrations. In many instances the condition of the patient forbade more than a hurried snapshot under unfavorable conditions of light, and for this reason the results have not been such as could be utilized in this work. The pictures have been taken of medical and surgical cases alike entering the services of the physicians and surgeons on duty in the hospital, and I desire to thank these gentlemen in general, as in a previous paragraph I have done by name, for permitting me to use the material in their respective services. A certain proportion of the photographs were taken by the author himself, as well as many of the X-ray pictures.

The author wishes to thank Dr. James H. Kenyon for reading and correcting the manuscript, and for aid in many other ways.

The author desires especially to express his gratitude to Dr. Charles McBurney for a large collection of photographs accumulated during his long and distinguished career. He also wishes to thank him for the advantage enjoyed throughout a period of many years by a close association with him in surgical work, thereby enabling the author to collect many of the data of surgical diagnosis embodied in this work.

He wishes to thank Prof. George S. Huntington, the head of the anatomical department of the Columbia University Medical College, for many personal communications in regard to topographical anatomy, and for his kindness in permitting the author to utilize his article on "The Genetic Interpretation and Surgical Significance of Some Variations of the Genito-urinary Tract" in the section devoted to the Congenital Anomalies of the Kidney and Ureter.

The author wishes to express his gratitude to his sister, Alice G. Johnson, and to his wife, Louise T. W. Johnson, for practical aid and encouragement throughout the performance of a long and tedious task.

Alexander B. Johnson.

12 East Fifty-eighth Street,
New York City.

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SURGICAL DIAGNOSIS

VOLUME I

CHAPTER I

WOUNDS

Wounds—Definition and Classification.—A wound may be defined as a solution of continuity of the tissues of the body produced by traumatism, with or without a break in the skin or mucous membrane. When there is no break in the continuity of the surface, we speak of the injury as a *subcutaneous wound*, or *contusion*. When the skin or mucous membrane is broken, we speak of such injuries as *open wounds*.

Subcutaneous Wounds.—While wounds of either class may be of any degree of severity, subcutaneous wounds possess this peculiarity, namely, that they are not usually exposed to the invasion of pyogenic or other microbes from without, as is the case with open wounds, in which the skin or mucous membrane is broken. Consequently, in subcutaneous injuries, one of the greatest perils to which the human body is exposed is avoided almost completely; and yet, under certain conditions, subcutaneous injuries—notably if slight in character, and if they occur in parts where the blood circulation is naturally slow—do occasionally become infected. When wounds of this kind are superficial, and involve a portion of the thickness of the skin or mucous membrane, or if the nutrition of the skin is materially impaired, they may become infected from the bacteria in or upon the skin by continuity of structure. This is, however, an uncommon occurrence; and, although subcutaneous injuries may be accompanied, as we shall see later, by constitutional disturbance, their infection is comparatively rare. If so be that the patient has a suppurating focus in some other part of the body, the subcutaneous wound may still heal, and usually does heal, without difficulty.

There is, nevertheless, an infection which takes place through the blood in subcutaneous injuries, both by pyogenic and other microbes. A common example of this kind of infection is the acute purulent infection of the shafts of the long bones in children (the acute suppurative osteomyelitis). The disease commonly begins near the ends of the shaft of the bone, and quite often follows some slight injury. The same is true of tuberculosis of the bones. In these cases we must assume that the injury has produced a place of diminished resistance, and that the bacteria circulating in the blood have found here a favorable soil for their development. Such bacteria, in the case

of tuberculosis, often originate in a tubercular lymphatic gland, situated in the mediastinum or elsewhere.

Open Wounds.—These may be classified for purposes of description into those caused by blunt violence, such as blows with clubs, falls, and crushing injuries, known as *contused* and *lacerated wounds*, and wounds caused by sharp instruments, such as knives, swords, daggers, and the like; and these may be subdivided into (1) those in which the length of the wound is greater than the depth, or relatively large compared with the depth—*incised wounds*—and (2) wounds in which the depth greatly exceeds the size or caliber of the wound canal—*punctured wounds*. If some specific poison is introduced into the wound at the time of its infliction, it is called a *poisoned wound*. Snake bites, insect stings and bites, and wounds from poisoned arrows are of this class. Still another class of wounds are produced by missiles fired from guns and rifles. They partake both of the character of punctured wounds and of contused wounds. We may speak also of *simple* and of *complicated wounds*. An ordinary cut involving the soft parts is known as a *simple incised wound*. If, however, a joint or one of the cavities of the body is also wounded, we speak of the wound as a *complicated wound*. In reference to certain parts of the body—notably the abdomen, the thorax, and the skull—we speak of a wound as *penetrating* or *nonpenetrating*, as the case may be; or if the wound passes entirely through the wounded part, we speak of it as a *perforating wound*.

A very important distinction to be drawn in regard to wounds depends upon whether they are clean wounds, such as are made by the surgeon during properly performed operations, or whether, on the other hand, they are soiled with foreign material, contain foreign bodies, or are actually infected with pyogenic or other microbes. All accidental wounds are properly regarded as possibly infected wounds, and in general are treated accordingly. The signs and symptoms belonging to all wounds which involve the skin or mucous membrane are three: namely, gaping, pain, and hemorrhage.

SUBCUTANEOUS INJURIES

Signs and Symptoms.—The signs and symptoms of subcutaneous injuries vary greatly with the severity of the violence applied, and with the part of the body injured. A discussion of this topic will fall more properly under the head of Regional Surgery. A few only of the characters of such injuries may be mentioned here.

Pain in Subcutaneous Injuries.—Pain is a very constant symptom of subcutaneous injuries. It varies greatly with the character of the tissues injured. Contusions of those parts richly supplied with sensitive nerves are very painful injuries; for example, contusions of the fingers and toes, contusions of the bone, of some portions of the face, and of some other regions. The pain of contusions is due in part to the injury of the nerves, and in part to the pressure

produced by the blood poured out from the torn blood-vessels upon the nerve endings of the injured part. This pain, due to the pressure of effused blood, varies greatly in different regions of the body, and this depends partly upon the nerve supply of the injured region and partly upon the density or laxity of the tissues. An injury of the subcutaneous tissues of the arm or leg may be accompanied by but little pain, although the quantity of effused blood is considerable; the tissues are lax, and the effused blood easily finds its way through the tissues. A contusion, however, of the end of the finger, with the effusion of a few drops of blood only, between the finger nail and its matrix, is a very painful injury indeed.

Effused Blood in Subcutaneous Injuries.—Certain special signs and symptoms due to effused blood in certain regions will be referred to more especially under the head of Regional Surgery. For example, a quantity of blood poured out into the interior of the skull may produce serious, or even fatal, symptoms, although the amount of blood be small. When blood is extravasated into the subcutaneous tissues in considerable quantity, it forms a circumscribed elastic tumor beneath the skin, giving signs of fluctuation. If such a tumor communicates with an artery of considerable size, it may even pulsate, and may form what is known as an aneurism, or arterial hematoma (see Aneurism).

Ecchymoses in Subcutaneous Injuries.—Ordinarily blood extravasated beneath the skin makes its way rather rapidly through the meshes of the connective tissue in the vicinity, and is absorbed in from a few days to a few weeks, according to the amount of blood and the situation. Some of the blood finds its way to the surface, and produces a characteristic discoloration of the skin (ecchymosis). The color is at first dark red, blue, or purple, and within twenty-four or forty-eight hours the edge of the ecchymosed area becomes lighter in color and of a violet hue, and the discoloration increases in size. As the days go by the edge of the discolored area becomes yellow, while the central portion becomes, first brown, then green, and finally yellow, this being the last color to disappear. In vascular regions, where absorption takes place rapidly, these color changes may be passed through in a few days. In the subcutaneous tissues of the extremities, however—notably in the leg—the discoloration may last for many weeks. The effused blood travels beneath the surface to some extent by gravity; hence, an injury of the shoulder may give rise to ecchymosis of the elbow and forearm, which may not appear for several days after the injury. The different shades of color are due to gradual changes in, and the absorption of, the pigment of the blood.

Subcutaneous Injuries to Muscles.—Subcutaneous injuries may be of any possible degree of severity. They may consist of merely the rupture of a few minute blood-vessels beneath the skin, or the fascia covering the muscles may be ruptured, sometimes with the production of a hernia of the muscular belly through the rent, to be recognized by the formation of a soft swelling, noticeable chiefly when the muscle is put in a state of contraction. Muscular bellies, also, may be torn completely or partly, and tendons ruptured or torn away from

their attachments to the bone. If a muscle of considerable size is ruptured, a cavity or hiatus may be very distinctly felt by passing the fingers along the limb and making gentle pressure. When the site of the rupture in the muscle is reached, some tenderness will be complained of, and the fingers of the examining hand will sink more or less deeply into the gap. Loss of function of the muscle, or weakness, may also be demonstrated, and that portion of the muscle which still contracts under the control of the will may form a visible and palpable tumor.

Subcutaneous Injuries to Tendons.—If a tendon is ruptured or torn from its bony insertion, the formation of a tumor will usually be observed when the muscle contracts, and in case the tendon is the sole insertion of the muscle, loss of function will be complete in that muscle. Such ruptures may occur from direct violence, or from a violent contraction of the muscle itself. The ligamentum patellæ, the biceps tendon of the arm, and occasionally other tendons are torn in this way.

Subcutaneous Injuries to Nerves.—These may be of the nature of contusions, more or less severe, or of actual crushing and total destruction of nerves, or of ruptures of the nerve fibers, with or without simultaneous rupture of the nerve sheath. Dislocation of certain nerves—notably of the ulnar nerve where it passes behind the internal condyle of the humerus at the elbow—have occasionally been recorded. Such dislocation may occur from direct or from muscular violence, and the dislocated nerve may sometimes be felt as a tender cord beneath the skin. The symptoms of contusions of nerves vary with the severity of the injury. If the nerve has been merely bruised and not actually destroyed, the immediate symptoms will be a feeling of numbness, sometimes also of heat, in the parts supplied by the nerve. Tingling and prickling sensations will also be felt. Later there may be anesthesia, hyperesthesia, and paralysis, sometimes muscular spasms and disturbances of nutrition in the part which the nerve supplies. If the nerve fibers are actually destroyed, atrophy of the muscles supplied by the nerve follows with reaction of degeneration.

The motor symptoms are more marked than the sensory. This is explained by some observers on the ground that the sensory nerves anastomose more freely than do the motor nerves, and by others on the ground that a more perfect conducting power is necessary to conduct motor influences (see also Neuritis). The degree of destruction to which a nerve trunk has been subjected cannot always be recognized at once when the injury is subcutaneous. If some sensation remains, and not all the muscles supplied by the nerve are paralyzed, the nerve has not been completely destroyed, and the prognosis is not unfavorable. If, on the other hand, the parts supplied by the nerve are entirely painless and insensitive, and if complete paralysis of the muscles supplied by the nerve is present, and if rapid and complete wasting of the muscles occurs, the nerve is destroyed. (The Injuries of Special Nerves will be spoken of under Regional Surgery. Injuries of Bones and Joints will be spoken of under separate headings.)

CONTUSED AND LACERATED WOUNDS

Contused and lacerated wounds occur, as already stated, from the effects of blunt violence. They are interesting to the surgeon from a diagnostic point of view for a number of reasons. These wounds, from the manner of their infliction and from the diminished vitality of the tissues, are frequently infected. The infected material is frequently so pressed into the tissues at the time the injury is received that it is impossible entirely to remove it. The contusion and laceration of the tissues is such that the vitality of the injured part may be impaired or lost over an area large or small. The integrity of an entire limb (or the life of the individual) may be endangered. The intelligent care of injuries of this class demands a high degree of skill and judgment on the part of the surgeon.

Character of Contused and Lacerated Wounds.—In the examination of contused and lacerated wounds, a number of questions will arise for solution. Some of these will be considered here, and some may more properly be spoken of under Regional Surgery. In the first place, the surgeon will remember that, in the examination of these wounds, the same technic must be carried out as accompanies any aseptic surgical operation. No wound, fresh or old, is so dirty or so infected but that further infection is possible. In contused and lacerated wounds there is added the necessity of removing, as far as may be, foreign bodies and infected materials introduced at the time of the injury or later. It is astonishing how much may be accomplished in this direction if only sufficient care and pains be taken. In these wounds it often happens that the wound of the skin is comparatively small, while the stripping of the skin from the deeper parts and the injury to the deeper structures is extensive. In such cases the skin wound may be enlarged to a sufficient extent to permit free inspection of the deeper structures; the skin incision should be made in such position and direction that the blood supply of the skin will be preserved as far as may be.

To determine to what extent the vitality of the skin has been destroyed by the injury in recent cases is not always easy. The surgeon may be assisted in his judgment by certain simple observations. In some regions of the body the skin and subcutaneous tissues have an extraordinary vitality, due to their abundant blood supply. The scalp, the face, the tongue, the scrotum, the penis, the palm of the hand, and fingers and toes, are notably well supplied with blood; and a degree of contusion and laceration which would lead to necrosis in other regions may be, and often is, recovered from in these parts. If flaps of skin and subcutaneous tissue are stripped up, their survival is rendered more probable if the blood supply runs into the base of the flap rather than in the opposite direction. If the skin is extensively stripped up, and at the same time *separated* from the *subcutaneous tissues*, this indicates that the blood supply of such skin is probably destroyed, and that such a flap of skin will probably become necrotic, either wholly or in part. Skin and subcutaneous

tissues which are frayed out and shredded into a fibrous fringe, are unquestionably dead.

The vitality of tendons is remarkable, although their blood supply is small. If they can be covered by living healthy tissues and their continuity is not destroyed, it may generally be assumed that they will live, and that their function will be more or less perfectly preserved. Muscular tissue which is pulpified will usually not survive; but if sound muscular tissue exist above and below the point of injury, and the nerve supply of the muscle is intact, a fibrous splice may take the place of the divided muscle, or union by suture may result in a useful muscle. As has been stated under the head of Subcutaneous Injuries, a nerve trunk may be contused with only temporary disability, or its nerve fibers may be destroyed with preservation of the fibrous sheath. The diagnostic conclusions to be drawn from the mere appearance of such a nerve in a recent wound are not definite, unless the nerve trunk be actually severed, when it is certain that motor and sensory paralysis will result, and be permanent, unless the divided ends are united by suture.

Injuries of the Blood Vessels in Contused and Lacerated Wounds.—Such injuries are of the greatest diagnostic and prognostic importance. While such wounds may bleed freely and even fatally, the hemorrhage is generally far less than is the case with incised wounds. The vessels are often torn across or crushed in such a manner that the coats of the arteries become twisted, contracted, and retracted, and in many instances the ends of the torn vessels are either wholly or partly closed, and bleeding is slight or absent. I have seen several instances in which the entire upper extremity had been torn off by machinery, or crushed off by the wheels of a railway carriage, and no bleeding has occurred from the axillary artery. The end of the vessel could be plainly seen in the wound, either pulled out into a solid cord or twisted in such a manner that no blood escaped.

In the examination of such wounds, if superficial and of moderate extent, the source of bleeding, if such exist, is usually easily seen, whether from arteries or veins. If the injury involves the cranial cavity or thorax or abdomen, special diagnostic signs and symptoms exist which will be discussed under Regional Surgery. In injuries of the extremities, if extensive, the condition of the main artery of the limb, and consequently of the nutrition of the extremity, may generally be inferred by finding pulsation in the radial and ulnar artery at the wrist, or the dorsalis pedis and posterior tibial at the ankle, as the case may be. If such pulsation is present, the limb will probably retain its vitality, if infection can be avoided. Absence of such pulsation, together with coldness of the fingers or toes and paleness of the hand or foot, indicates serious impairment of nutrition. Destruction of both the main artery and vein of the limb is of most serious import. Destruction of the artery alone is less so, and destruction of the axillary or femoral vein, with preservation of the artery, are still less threatening; but any one of these conditions may involve partial or complete loss of nutrition of the limb.

An observation made when I was interne in Bellevue Hospital is suggestive and instructive. A large, well-nourished man, thirty-eight years of age, was brought to the hospital suffering from a severe contused and lacerated wound involving the soft tissues above and below the right elbow-joint. On the anterior aspect the skin was extensively stripped up from the deeper tissues along the front of the limb for a distance of six inches. The flexor muscles of the forearm were stripped of their fascial covering over a similar area. The bones were uninjured. The elbow-joint was not opened. The wound had been received within an hour from the time the patient entered the hospital. On the inner side of the limb the lower two inches of the brachial artery were exposed in the wound, and the vessel was separated for a like distance from its attachments. The vessel pulsated freely, and the pulsations of the radial and ulnar arteries at the wrist were easily felt. The wound was cleansed and dressed carefully according to the methods in vogue at that time (1886). Within twenty-four hours the pulsation of the radial and ulnar arteries at the wrist had ceased, and the hand had become cold. Examination of the wound showed that the brachial artery no longer pulsated. It had become filled with a thrombus. Later the forearm became gangrenous; a mixed sapremia and septicemia occurred. Amputation was done at the upper third of the arm. The patient did not survive.

Infection of Contused and Lacerated Wounds.—Contused and lacerated wounds, from the nature of their production and from the diminished vitality of the tissues, are not only more apt to be infected than other wounds, but the infection is of a more serious character. The pyogenic cocci find a favorable soil for their development, as do also other infectious germs and saprophytes. The diagnosis of infection in such wounds is usually easy. They are peculiarly liable to the spreading phlegmonous or necrotic infections caused by Streptococcus pyogenes, to cellulitis, lymphangitis, to pocketing of pus due to the irregular shape of the wound cavities, and to constitutional infections, septic intoxication, sapremia, septicemia, and pyemia (see diagnosis of these diseases). The constitutional depression following immediately upon the receipt of these injuries is often grave, irrespective of injuries of special organs.

Diagnosis of Contused and Lacerated Wounds from a Medico-legal Point of View.—In the diagnosis of contused and lacerated wounds it sometimes happens that from a medico-legal point of view it is important to know the character of the instrument which produced the wound. In this connection it is to be remembered that stones, sticks, clubs, and the like, when brought into violent contact with a layer of soft parts covering bone, may produce a wound which closely resembles in shape the outline of the object which caused the wound. This is especially noticeable in wounds of the scalp, where the soft parts are cut between the object and the surface of the skull along the line of contact. Under such circumstances the shape of the wound may accurately represent in size and shape the end of the stone, club, or the like, with which a blow was struck. Moreover, such wounds may be linear in form, and may

show very little contusion of the wound edges: they may closely resemble wounds made by a sharp instrument.

INCISED WOUNDS

Incised wounds are those made by sharp or cutting instruments: knives, swords, pieces of glass, etc. They are such wounds as are made by the surgeon's knife. They possess several characters which serve to distinguish them. Among these are pain, a marked tendency to gape, and bleeding.

The Pain of Incised Wounds.—It is most acute at the moment of their infliction. The sharper the instrument the less the pain. The skin, the nerves, and bone are the most sensitive structures when cut. Those regions of the body most plentifully supplied with cutaneous nerves hurt most when cut: the face, the genitals and anal region, and the fingers and toes. The pain of an incised wound diminishes to a dull ache soon after the infliction of the injury, and soon disappears entirely, unless irritated, mechanically by motion, chemically by dressings, or by infection. The after pain of even so extensive a wound as an amputation of an extremity is not usually severe, and subsides entirely in twenty-four hours or less, if *infection* does not occur.

A very valuable diagnostic sign, then, in the case of incised wounds is the presence or absence of pain during the days following their infliction. If no spontaneous pain exists, and no marked tenderness on pressure, the surgeon may, with certain exceptions, feel assured that the wound is not infected, is doing well, and does not need to be inspected or disturbed, except in cases where the patient is unconscious, or where strangulation or gangrene of an entire limb may be present. This absence of pain is one of the most valuable guides in the treatment of incised wounds. The pain of divided sensitive nerves is acute at the moment of infliction, but subsides speedily if the nerve be clean-cut and completely divided. Loss of sensibility will, of course, be noted in the area supplied by the nerve.

The Gaping of Wounds.—The gaping varies much in different regions of the body, also according to the depth and direction of the wound. In situations where muscular layers are intimately adherent to the skin, incised wounds gape much more when made across the line of the muscles than when made parallel to the direction of their fibers. Wounds made in the long axis of a limb gape less, as a rule, than do wounds made transversely thereto.

Bleeding.—The rapidity of bleeding from a recently incised wound depends upon the number and size of the blood-vessels divided. The character of the bleeding varies with the character of the divided vessels—whether arteries or veins. A third variety of bleeding is sometimes known as parenchymatous bleeding. It occurs from certain regions, notably the corpora cavernosa penis and corpus spongiosum, the mucous membrane covering the turbinated bones of the nose, and some of the glandular organs of the abdomen. The blood is a mixture of arterial and venous blood from small but numerous vessels of both

kinds. A fourth kind of bleeding occurs as an oozing from the smallest blood-vessels, the capillaries, and only under exceptional circumstances is it of serious significance. Loss of blood is well borne by strong, healthy adults; better by women than by men; badly borne by infants and persons of advanced age.

The Division of Muscles and Tendons in Incised Wounds.—Division is to be recognized by loss of function of the injured muscles and by seeing the cut structures by direct inspection of the wound. During inspection of an open wound the cut surfaces of divided muscles can hardly escape observation, but divided tendons may escape the notice of a careless surgeon. This is notably true in wounds of the hand and wrist, where numerous tendons are present. The proximal portion of the tendon may often be retracted out of sight into its sheath, and the distal portion may be partly or entirely hidden by overlying parts, or on account of the position of the limb. It is therefore wise to test the function of all the muscles which might be injured in a wound, and to make the inspection of the wound in a careful and systematic manner.

The Division of Nerve Trunks in an Incised Wound.—This may be recognized partly by direct inspection and partly by loss of function, motor and sensory, of the affected nerve. As pointed out under the head of Contused and Lacerated Wounds, the loss of motor function is apt to be more complete than is the loss of sensibility, and is a more dependable and positive sign. The motor paralysis in cases of division of large nerve trunks is quite characteristic. In addition to paralysis of motion and sensation, the area supplied by the divided nerve usually feels subjectively and objectively colder than normal; rarely there may be a temporary increase of temperature. After the paralysis has existed for some days, changes in the nutrition of the skin may occur: the skin may perspire abnormally or be abnormally dry; the surface may be unnaturally pale, or blue and cyanotic; atrophy and even gangrene of a portion of an extremity may occur, this being notably the case in the fingers and toes; chronic ulcerations may form in parts subjected to pressure. Later on, disturbances in the nutrition of the bones and the joints are common, leading sometimes to chronic effusions into the joints, later to ankylosis, and the paralyzed portion of the limb may undergo atrophy of all its structures.

PUNCTURED WOUNDS

Punctured wounds are of small caliber and of relatively great depth. They are produced by stabs with slender objects, such as knife blades, daggers, and the like, and by blows with, or falls upon, pointed sticks, needles, and similar bodies. The skin orifice of a punctured wound represents with fair accuracy the size and shape of the instrument which created the injury. Punctured wounds present a number of interesting diagnostic features. Such wounds frequently penetrate the body cavities: cranium, thorax, abdomen, and the large joints. The discussion of the diagnostic features of such penetration belongs properly under the head of Regional Surgery, and will be there con-

sidered. A portion of the instrument producing a punctured wound may be broken off in the tissues, and remain embedded in the depths of the wound. For this reason it is desirable, if possible, to inspect the instrument which caused the wound, to see if it is entire, and, by a careful examination of the part wounded, to exclude the presence of a foreign body.

Localization of Foreign Bodies in Punctured Wounds.—Slender foreign bodies like needles may remain indefinitely, if clean, embedded in the tissues, and may wander slowly or quite rapidly to near or distant regions; muscular action hastens or causes this result. When a patient presents himself with the history that a needle, or the like, has become embedded in the tissues, it is unwise to assume that the position of the object has remained unchanged since its introduction. Before making an effort to remove such an object through an incision, it should be accurately localized. Failure to do this will often lead to fruitless search in the vicinity of the original wound for an object already some distance away. By palpation the presence of such foreign bodies may sometimes be detected. Sometimes pressure made upon a particular point or in a particular direction may elicit pain, and serve as a guide to a foreign body. If the body be a piece of metal or glass, it may be detected by the X-rays by a radiograph; less easily by the use of the fluoroscope (see X-rays in Surgical Diagnosis). The danger of serious infection from splinters of wood, nails, etc., permitted to remain in punctured wounds, is very great. Such bodies are commonly contaminated with pyogenic germs, and sometimes with tetanus.

Punctured Wounds of Arteries.—Aside from the presence of foreign bodies in punctured wounds and the perforations of body cavities and joints, the most important complications of punctured wounds, of diagnostic interest, are injuries of blood-vessels and of nerves. A punctured wound of a large artery is usually followed by a gush of bright arterial blood as the weapon or instrument is withdrawn from the wound, but such external bleeding soon ceases, as a rule, and one of several events may follow. If the wound in the artery is small, the orifice may be temporarily or permanently closed by a clot, and healing may take place without further hemorrhage.

Traumatic Aneurism—Arterial Hematoma.—If the wound in the wall of the artery is large, the blood will continue to escape, but instead of finding its way through the narrow canal to the surface, it may form a tumor of greater or less size, due to the accumulation of blood among the deeper tissues. Such a tumor may be of any size, depending largely upon the size of the blood-vessel wounded and upon the character of the surrounding tissues. The tumor will be tense and elastic, but will not usually afford the sensation of pulsation such as is found in true aneurism, until it has reached a considerable size. Such a tumor is known as a traumatic aneurism or arterial hematoma or primary aneurismal hematoma. In traumatic aneurism, auscultation with a stethoscope over the tumor usually permits one to hear a whirring or whizzing murmur, synchronous with the systolic contraction of the heart or with the pulse. This systolic murmur is caused by the escape of the blood through the

orifice in the vessel into the surrounding tissues; it ceases at once if the main arterial trunk be compressed upon the proximal side of the injury. If the wound in the artery becomes closed by a thrombus, the tumor will persist, but no murmur will be heard.

In a case which came under my observation, the deep femoral artery had been accidentally punctured by the blade of a scissors in Scarpa's triangle. The wound in the skin was very small, and did not bleed. Within twenty-four hours the upper portion of the thigh was greatly swollen, and a distinct murmur could be heard upon applying the stethoscope to the front of the limb, over the course of the vessel near the wound. Exploration showed that the tumor consisted of a large quantity of clotted and fluid blood. The puncture in the wall of the artery was about an eighth of an inch in length.

Aneurismal Varix and Varicose Aneurism.—If a punctured wound injures a large artery and a neighboring vein at the same time, a communication (which is sometimes permanent) may be established between the artery and the vein (see Aneurism).

Punctured Wounds of Veins.—These alone usually give rise to only moderate bleeding, and such bleeding can generally be readily controlled by pressure (see Varicose Veins). The color of the blood, the continuous character of the blood stream, and the moderate force of the same, usually suffice for a diagnosis.

Punctured Wounds of Nerves.—Punctured wounds of nerves give rise to symptoms which depend upon the number of nerve fibers divided. If the nerve be completely divided, the symptoms will be the same as is the case with incised wounds of nerves. It sometimes happens, however, in punctured wounds that only a portion of the nerve trunk is cut or injured; under these circumstances the paralysis of the nerve will not be complete. The practical bearing of this is that such nerves frequently heal completely with regeneration of the injured fibers without artificial aid. Occasionally, however, such an injury may give rise to the formation of a fibro-neuroma; to the formation of scar tissue in and about the nerve, accompanied by local pain and tenderness, sometimes of a very severe character; and to the occurrence of painful spasmodic contractions of the muscles supplied by the nerve. Such tumors formed upon a nerve trunk may necessitate a dissection to free the nerve from the pressure of the scar tissue, or even resection of the entire nerve trunk may be required in certain instances, with subsequent suture.

The Diagnosis of Pyogenic Infections in Punctured Wounds.—The diagnosis is to be made from the same signs which are present in other infected wounds, namely, by the presence of the signs of inflammation in the vicinity of the wound, and by constitutional disturbances, fever, etc. In some instances the local signs of inflammation may be less evident than in open wounds. This is not only true of punctured wounds of joints and body cavities, but also of deep punctured wounds elsewhere. The orifice of the wound may appear clean or even healed, although the deep portion of the wound may be the seat of abscess or of spreading necrotic inflammation. The signs of pain and tender-

ness will, however, be marked, and the constitutional disturbance will often be severe. Some of the most dangerous and fatal forms of infection follow small punctured wounds, such as occur from a needle puncture of a finger during surgical operations and autopsies made upon those ill or dead of acute septic processes of various kinds. In these cases the local reaction in the wound may be so slight as scarcely to be noticeable, and the sudden advent of grave constitutional symptoms may be the first indication of trouble (see Septic Intoxication, Septicemia, etc.).

POISONED WOUNDS

We use the term poisoned wounds here to indicate that some specific poisonous material is introduced into the wound at the time of its infliction other than bacteria or their toxins, and include under the head of poisoned wounds snake bites, poisoned arrow wounds, and the bites and stings of insects.

Snake Bites

The diagnosis of snake bites is usually entirely simple. The history leaves the matter in no doubt. The symptoms of poisoning occur, for the most part, very soon after the injury, and are characteristic. The matter of treatment is of far greater consequence than the entirely evident diagnosis. The question may, however, arise as to whether the snake was poisonous or not, and this may sometimes be determined by a few simple data given below. Inasmuch as the United States has assumed control of a number of tropical countries where poisonous snakes abound, the matter of snake bites assumes a new interest for American surgeons. In the Philippine Islands the cobra and other allied Indian species are fairly numerous, and on the Isthmus of Panama there are many poisonous snakes. The number of poisonous snakes in the United States itself is considerable. They are more abundant in the southern and western sections of the country than in the east and north. Owing, however, to their rather sluggish habits, many of them, although their venom is deadly, are not so dangerous as in tropical countries where poisonous snakes are not only numerous, but exceedingly active and hostile to man.

That order of the Reptilia known as snakes, or "Ophidia," is divided into two suborders: the Colubrides, many of them harmless, and the Vipers, all of them poisonous. The only marked distinction between the poisonous and nonpoisonous snakes is the presence in the poisonous varieties of poison glands, of poison fangs, and of a muscular apparatus for the injection of the poison. Nonpoisonous snakes have poison glands, but since they do not communicate directly with the fangs the bites of such snakes are harmless. The poison appears to be necessary to them for purposes of digestion. A broad distinction may be made between the poisonous and the nonpoisonous snakes, according to the arrangement of the teeth. In the nonpoisonous snakes there are two complete rows of teeth—maxillary and palatine—arranged in two nearly paral-

lel rows. The palatine teeth number from thirty-five to forty. The teeth are all small as compared with the size of the poison fangs of the venomous snakes. The only poisonous snakes having a similar arrangement are the poisonous sea snakes (Hydrophidæ). The poisonous snakes have fewer palatine teeth, the Colubrides have about twenty-five, and the Vipers from eight to ten. In the Vipers, the maxillary teeth consist of two mature, long, sharp, recurved, hollow poison fangs rigidly articulated to the movable maxilla. The duct of the poison gland empties into the base of the hollow fang. When at rest, the fangs lie embedded in the folds of the lining membrane of the mouth. When the snake opens its mouth to strike, the movable maxilla is rotated so that the fang is erected and projects forward.

In some of the viperine snakes a series of undeveloped poison fangs, two or more in number, lie behind the mature fangs, and take their place if the latter are shed or injured. The fangs of the Vipers, together with the poison glands, form a mechanical arrangement closely resembling in its action that of a hypodermic syringe. At the moment of striking, the fangs are erected and the contents of the poison glands are ejected by a rather powerful muscular apparatus, chiefly by the contraction of the temporal muscles. As the fangs reach their mark the lower jaw is raised, thus pressing the upper jaw against the part struck and insuring penetration, at the same time forming a *point d'appui* for the contraction of the temporal muscles, which not only compress the poison glands and eject the poison, but also render the penetration of the fangs deeper.

In some species the poison may be expelled to a distance of several feet.

Colubrine Snakes.—The Colubrine snakes have two, sometimes three, maxillary fangs on either side. The anterior fang is grooved for the conduction of the poison. The fangs are shorter than those of the Vipers, and are immovable. In only one group of poisonous snakes among the Colubrines is this arrangement of the teeth departed from. Among these there are several long, grooved poison fangs in the back of the mouth, while in front there are two smooth, nongrooved teeth. Owing to the position of the poison fangs these snakes are seldom dangerous to man. It will thus be seen, speaking broadly, that when an individual is bitten by a snake the tooth marks may furnish fairly positive proof as to whether or not the bite is dangerous. (See Fig. 1, showing the most frequent arrangements of the teeth in the poisonous and nonpoisonous snakes, respectively.) Where only two good-sized punctures, side by side, are produced, it is certain that the bite is poisonous.

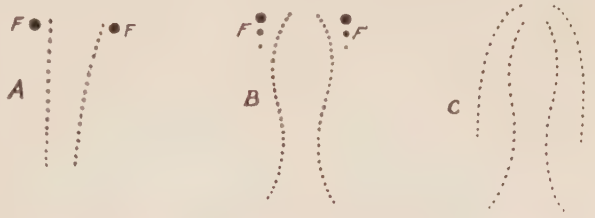

FIG. 1.—DIAGRAM TO ILLUSTRATE THE GENERAL ARRANGEMENT OF THE TEETH IN POISONOUS AND NON-POISONOUS SNAKES. *A*. Viper. *B*. Cobra. *C*. Nonpoisonous Snake. *f*, Poison fangs.

The characters of the more important poisonous snakes are as follows: Among the Colubrides, the Proteroglyphia (having grooved teeth) are the most important. They have well-developed fangs, grooved along the entire anterior surface, situated near the front of the upper jaw. These teeth are connected with the excretory ducts of the poison glands; the latter are highly developed. Of these snakes there are five families. The two most important are the Hydrophidæ, or sea snakes, all poisonous, and the Elapidæ, or land snakes.

Hydrophidæ.—In the Hydrophidæ the head is narrow, the back elevated into a ridge, and the tail compressed laterally to aid in swimming. The eyes are small and the pupils round. These snakes swim very rapidly, although slow and clumsy upon the land. They live in large colonies, swim far out to sea, and are exceedingly bold and vicious. They inhabit the tropical sea-coasts of Asia and the tropical islands of the Pacific.

Elapidæ, or Land Snakes.—These furnish the most dangerous snakes in the world, including the cobra—Naja tripudians, Cobra de capello, Hooded Cobra. They have a slender, cylindrical tail, smooth or wedge-shaped scales; some of them, when excited, spread the neck laterally until it is wider than the head. The expansion is produced by a movement of the elongated first few pairs of ribs; these are brought forward at right angles to the spine, thus forming the so-called hood. These snakes are found in Asia, Africa, North and South America, and Australia. In America many of them are known by the name of coral snakes. The true coral snakes, however, are found only in the forests of tropical South America and in the State of Florida.

The American members of the genus Elaps are small snakes, not exceeding three feet in length; they live in the woods; their poison is very powerful, but, owing to the position of the fangs far back in the mouth, they are not very apt to produce a fatal bite. Two species are common in the Southern and Western States. The best known is the Harlequin Snake; it is abundant in Arizona; its bite is sometimes fatal to man. Most of the dangerous snakes of India are Elapinæ. Among the genera are Bungarus, Naja, and Callophis. Bungarus and Callophis are far less dangerous to man than Naja.

Bungarus cœruleus (Krait).—This variety of snakes is, however, responsible for many deaths. It is a small snake, of dull coloration. The fangs are smaller than in the cobra, and do not penetrate so deeply; but, according to Fayrer, it is, next to the cobra, the most dangerous snake to human life in India.

Naja tripudians.—This best known and most dreaded of all reptiles is abundant in India, Burmah, and the Malayan archipelago. They have a pattern on the back of the neck resembling a pair of spectacles. They are also found throughout every part of tropical Asia. They lay about twenty soft eggs the size of a pigeon's egg. The cobra is not afraid of man, and will enter houses at night in search of rats, mice, or other food. If not molested, they are said to live at peace with the human inhabitants.

A closely allied species, much larger in size though by no means as numerous, is Hamadryas ophiophagus elaps—snake eater. This snake grows to a length of fourteen feet; it much resembles the cobra in range and habits, but owing to its size is more dangerous. Its favorite food is other snakes. It is valued by snake charmers on account of its docility in captivity. They are careful to extract the fangs.

In Africa there are a number of species closely allied to the Indian cobra; among the best known is the Egyptian cobra, or asp—Naja Haje. The snake grows to a length of six feet. Other species of Naja are abundant throughout equatorial Africa.

All the poisonous snakes of Australia are Colubride snakes. The most common are the Black Snake, Tiger Snake, and Death Adder (Pseudechis porphyriacus, Hoplocephalus curtus, and Acanthophis cerastinus).

Viperidæ.—All the viperine snakes are poisonous. They comprise the Viperidæ and Crotalidæ. They are distinguished by a short triangular head and a stout body with a short tail. The poison fangs are long and well developed; they are hollow, not grooved. The bones of the upper jaw are movable, and the fangs are erected by muscular action. These snakes abound in Europe, Asia, Africa, and America, but are not found in Australia. This group contains nearly all the important poisonous snakes of America.

In America there are no true vipers, but the Pit vipers are very common. They have a very broad head, imperfectly covered by scales, and are characterized by the presence of a deep pit on either side, behind the nostril and in front of the eye. Some of them have a series of horny, loosely jointed rings at the end of the tail. When the snake is startled or excited it vibrates the tail rapidly, and the peculiar sound thus produced gives origin to the name rattlesnake. There are three genera: Crotalus, Lachesis, and Ancistrodon.

Crotalus.—This snake is found only in America, throughout the United States as far north as New York, and in South America as far south as Brazil. There are in the United States some fourteen or more varieties of rattlesnakes. They are easily recognized by the presence of a jointed, horny rattle at the end of the tail, used by the snake to make known its presence and to warn intruders, and by the broad head, and the deep pit in front of the eye. The rattlesnake strikes from a coil by rapidly straightening the body in the direction of the thing to be bitten. They are unable to throw the entire body from the ground, and can only strike an object distant two thirds of their own length. The best known variety as well as the largest is Crotalus adamanteus, the Diamond-back Rattler. This snake may attain a length of about eight feet, this being, however, an unusual size. The fangs of such a snake may be a full inch in length. It is most abundant in the Southern States. The northern species—the banded rattlesnake, Crotalus horridus—is from three to four feet in length. It is very common in the Rocky Mountains, and in the desert regions to the west and south. Other varieties of the Pit Viper, less dangerous than the rattlesnake, are the Copperhead (Ancistrodon con-

tortrix), of a banded copper color, seldom longer than three feet, known also as the Pilot Snake, Upland Moccasin, and Deaf Adder, habitat the United States, east of the Rocky Mountains; the Water Moccasin (Ancistrodon piscivorus), habitat bayous and swamps in the Southern States, an ugly snake of a dirty brown or mud color, extreme length five feet, diameter three inches; it is also called Cotton-mouth, from the white color of the interior of its mouth.

A closely allied species is Lachesis (the Fer de lance, or Lance-headed Snake), a native of the West India Islands, extreme length, six feet; the head is wide, the fangs long, color brown, with black markings. In the Island of Martinique the snake has caused a considerable annual death rate among persons working on the sugar plantations.

One of the largest and most deadly of the Pit Vipers is the Lachesis Muta (or Lachesis rhombeata), sometimes called Surucucu, or Buschmeister (Bush Master). This snake inhabits the elevated woodlands in many of the tropical and subtropical countries of South America, Brazil, the Guianas, and neighboring States. It lives upon the ground, and is not a tree climber. It is said to grow to a length of eight feet or more, with a girth equal to that of a man's leg. The general form and habits of the animal are similar to those of the rattlesnake. It is a handsome snake. The back is colored a bright reddish yellow, with a longitudinal row of large rhombic, dark, blackish-brown spots, each with two small bright spots within its area. The end of the tail is armed with horny scales ending in a spine. The belly is bright yellow, or pearly. The snake is said to be very aggressive, sometimes lying quietly coiled until the near approach of an intruder, and striking like a flash when he comes within range, or in other instances advancing rapidly along the ground to attack man or lower animals. Unlike the rattler, there is no warning sound given by this snake. The symptoms come on soon after the bites; hemorrhages from mucous membranes, rigidity and loss of voluntary control of the muscles, are said to be marked symptoms. Death may occur in from six to twelve hours.

The true vipers are not found in America. They are, however, the only poisonous snakes of the Continent of Europe, and are represented by several species. The commonest is Vipera Berus. None of them are large snakes; they are seldom longer than two feet. They are found spread over the entire Continent, notably in mountainous regions. Various members of the viper family are found in Africa: the Horned Viper (V. cerastes) in the northern part; farther south, the Puff Adder (Bitis arietans). This snake attains a length of five feet. In striking it is said to throw its entire body off the ground, so that it might even wound a man on horseback. Its venom is used by the Hottentots to poison their arrow tips.

In India and Burmah there are found large vipers, Echidna Elegans, a richly colored snake, growing to a large size. Other and dangerous vipers are found in Japan and in Tibet.

Snake Venom.—Snake venom is a clear, watery or viscid fluid, of a pale yellow or amber color, of a specific gravity of from 1.030 to 1.070. It is higher in Crotalidæ than in Colubridæ, faintly acid in reaction. In the dried state the poisonous properties are preserved indefinitely. The dried venom breaks up into numerous minute flakes resembling dried egg albumin. Weir Mitchell preserved Crotalus venom for twenty-three years without perceptible loss of activity. Venom is not destroyed by light nor by freezing. It is destroyed by a temperature of 100° C. after a short time. Snake venom gives the ordinary proteid reactions. The amount of venom excreted at a single bite varies with the size of the snake, and with the time which has elapsed since the previous bite. Snakes in captivity sometimes deteriorate in health, and often refuse food. The quantity of the venom, and its toxicity, is thereby diminished. It is probable that more venom is furnished when the snake bites than when the poison glands are squeezed with the fingers and the venom thus obtained. The amount of venom yielded by squeezing the gland has been determined experimentally in a number of important snakes. The weight in the following figures is estimated in the dried state: Cobra, N. tripudians, 0.254 (Cunningham), from a bite 0.373 (Lamb); Lachesis, Fer de lance, 0.127 (Calmette); Crotalus adamenteus, 0.309–0.179 (Flexner and Noguchi).

The Chemistry of Snake Venom.—The chemistry of snake venom is but little understood. The general result of the several investigations which have been made is that venom contains two actively poisonous ingredients. They have been named Venom Peptone and Venom Globulin. The action of each of these is different; venom peptone causes edema, putrefaction, and necrosis of the tissues; venom globulin, on the other hand, acts through the nerves upon the muscles of respiration and the circulatory apparatus. It destroys the coagulability of the blood, causes ecchymosis, lowers the blood-pressure, and paralyzes respiration. While all snake venoms contain the same poisonous ingredients and have the same action upon the animal organism, yet it has been found that the venom of different kinds of snakes contain the poisonous principles in varying proportions, so that the symptoms produced will vary quite markedly after the bites of serpents of different kinds. The following details are largely adapted from the work of Flexner and Noguchi. The poisonous principles may, according to their action, be classified as follows:

1. A principle which produces instantaneous coagulation of the blood in the vessels.
2. A principle which acts upon the nervous system.
3. A principle which causes rupture of the walls of the capillary vessels and extensive hemorrhage.
4. A principle which causes solution of the blood-corpuscles.
5. A number of principles destructive to tissue cells.
6. A principle which causes hardening of the red blood-corpuscles.
7. Loss of the bactericidal property of the blood.

1. *The Blood-clotting Principle.*—The venom of certain snakes has a marked influence on the coagulation of the blood. In large quantities it causes instant coagulation of the blood within the vessels. In smaller quantities it destroys the power of the blood to coagulate for a long time. Venoms of this class are capable, under certain circumstances, of causing instant death by widespread coagulation of the blood. The symptoms produced are giddiness, loss of consciousness, general convulsions, and death in a few minutes. Death has been known to occur in half a minute. The blood is found coagulated in the vessels, more especially in the pulmonary arteries and the right side of the heart. The snakes capable of this form of poisoning are: Crotalus adamanteus, Daboia russellii, Bungarus fasciatus, Hoplocephalus curtus (an Australian snake), Tiger snake, Echis carinata (an Egyptian viper), Pseudechis porphyriacus, Black snake (Australia), Trimeresurus riukiuanus (a Japanese viper).

2. *The Neurotoxin of Venom.*—The venoms containing the largest proportion of this ingredient are those of cobra and Bungarus (Krait), though they are found in larger amount in all of the Elapidæ and Hydrophidæ than in the Viperinæ. These venoms may produce death in a few minutes. The smallest lethal dose of cobra venom causes death in two or three days. The local symptoms caused by neurotoxic venoms are trifling: slight edema, sometimes ecchymosis. The nervous symptoms are marked. They come on almost at once, and are stupor, muscular weakness followed by paralysis, twitching of the muscles, dyspnea, cessation of breathing, and death. A large dose of cobra or of Bungarus venom produces identical symptoms. A small dose of Bungarus venom causes a chronic form of poisoning. There may be no marked symptoms for several days, when muscular weakness, profound mental and physical depression, loss of appetite, and emaciation appear, and are progressive until death. The exitus may be delayed for a fortnight.

3. *The Principles Causing Hemorrhage.*—The poison of vipers and rattlesnakes is rich in this principle, and the most striking symptoms of rattlesnake bite are the profuse and continuous bleeding from the wound, and the rapidly progressive swelling and ecchymosis of the part bitten. The extent of the tissues thus affected varies according to the amount of the poison, but it may continue to advance for several days, involving the entire limb, or even the entire side of the body. The walls of the capillary vessels are extensively ruptured, and examination of the tissues shows that blood is extravasated into all the soft tissues of the limb. One of the worst features of rattlesnake bite is the extensive sloughing of the tissues thus affected, leading to loss of the limb or to deformity from extensive scarring, and consequent impairment of the muscular action. The principle producing edema is believed to be different from that producing hemorrhage.

Symptoms of Rattlesnake Bites.—The symptoms of rattlesnake bite may properly be described here. They are: immediate severe pain in the wound; wound continues to bleed; rapid swelling and ecchymotic discoloration of limb;

later, bloody exudation into mucous membrane of nose, mouth, conjunctiva, and hemoglobinuria; in fifteen minutes or more, prostration, nausea, vomiting; rapid fall of blood-pressure; respiration at first rapid, later slow and stertorous; muscles, sometimes convulsive twitchings, followed by paralysis. Death may occur in twelve hours. Recovery from the general symptoms of intoxication occurs suddenly. If the patient survives the immediate effects, suppuration, often extensive, sometimes gangrenous, occurs near the bite. Death may occur from septicemia. In cases where the venom is injected directly into a large vein, rapid general thrombosis may cause almost instant death.

4. *The Principles Causing Solution and Agglutination of the Blood Cells.*—The destruction of the blood cells is shown clinically by hemoglobinuria. Experimentally, this has been proven by bleeding a poisoned animal and allowing the blood to settle, when the serum is found to be blood-stained. The agglutinating property of the rattlesnake venom was demonstrated by Weir Mitchell in rabbits.

5. *Principles Causing the Solution of Tissue Cells.*—Flexner and Noguchi found in venom solvent agents which destroyed the cells of the liver, the kidney, testis, spermatozoa, and ova, but that these agents required certain complementary bodies to perform their solvent action. These bodies exist in the body fluids or in the cell body.

6. *The Protective or Hardening Property upon the Red Blood Cells.*—It has been demonstrated by numerous observers that when snake venom is added to blood, if the venom is present in large amount it appears to harden the red blood cells by forming, according to Noguchi, an insoluble compound or precipitate which prevents the escape of the hemoglobin from the cells.

7. *Loss of the Bactericidal Property of the Blood.*—Following snake bites, it has often been observed that, though the victim recovers from the immediate effects of the poison, he may die from a secondary pyogenic infection, and that under such circumstances there is little or no power on the part of the tissues for resisting the invasion of pyogenic and other bacteria.

The Symptoms of Cobra Poisoning.—The wounds made by the fangs are insignificant punctures. Burning pain and edema of the surrounding tissues follow. Constitutional symptoms may appear in from a few minutes to an hour. They are vertigo, weakness of the extremities, followed by complete paraplegia. There may be convulsive movements or general convulsions. There is ptosis, paralysis of the muscles of the jaw and throat, inability to speak or swallow. The pupils continue to react to light. Consciousness is preserved. The pulse is rapid, but is of fair force until just before death. There is finally paralysis of all the muscles. The respiratory functions are rapidly destroyed; breathing is at first rapid, becomes slower, labored, and more and more superficial until it ceases. The heart may beat for some minutes after breathing stops. The length of time after the bite before death occurs varies a good deal, according to the amount of venom injected. In most of the fatal cases death occurs in from two to twelve hours after the bite.

About one fifth of the cases die in less than two hours, and one fifth after twenty-four hours. Recovery, when it takes place, is rapid, and is not followed by the inflammatory local symptoms usual after rattlesnake bite.

Mortality.—It is believed that seven eighths of the cases of rattlesnake bites recover (Weir Mitchell). Other estimates are from fifteen to twenty-five per cent mortality. Cobra bites are fatal in from twenty-five to forty-five per cent of the cases (Calmette). Bites about the face are very dangerous, as are bites upon the toes and fingers, since the wounds here are often deeper, the size of the fingers being more favorable for deep penetration. The minimum fatal dose of cobra venom for a man is variously estimated at from 0.01 gm. (Calmette) to 0.0175 gm. (Lamb).

Treatment of Snake Poisoning.—A word in regard to the treatment of snake bites. If the bite is upon a limb, instant tight, elastic ligation of the limb above the bite should be practiced, or several ligatures may be applied, one above the other. If the bite is upon a finger, the snake a deadly and active one, and the wounds deep, probably immediate amputation of the finger or toe, as the case may be, would be the simplest and safest measure. It is dangerous to leave a tight ligature on a limb for more than half an hour. At the end of that time it should be loosened for a few moments and reapplied. If practicable, excision of the wound is a safe and proper measure. Cupping, or sucking with the mouth, is useful if done at once. The mouth should be rinsed with water or some antiseptic solution (potassium permanganate, 1–100). The wound may be destroyed with a hot iron or a hot coal. Certain chemicals have been much used by subcutaneous injection into and about the wounded tissues. They do no good if injected at a distance. The advantage of their use is that they may destroy the venom without seriously injuring the tissues. They should be used liberally, and at the earliest possible moment. Among those which have been found useful are potassium permanganate, 1–100; chloride of calcium or hypochlorite of calcium, 1–60; chloride of gold, 1–1,000; chromic acid, 1–100. If the wounded tissues are excised, potassium permanganate crystals may be rubbed into the raw surface.

General Treatment.—Stimulants of all kinds may be administered. Alcohol in full but not excessive doses, stopping short of profound intoxication; tea and coffee in large doses; strychnin as the result of experiment upon animals has not been found useful. It is nevertheless recommended in full doses by numerous observers. If respiration fails, artificial respiration should be used, and kept up as long as the heart continues to beat.

Specific Treatment.—The exact value of Calmette's antivenene injection for snake bite has not been definitely determined. It is contended by him that, although prepared by him as an antidote to cobra poisoning, it saves life after bites from this and also after bites from viperine snakes. It is, however, alleged by others that Calmette's antivenene is not sufficiently powerful in doses of 20 c.c. to save life after a human being has been bitten by a cobra. The average dose of poison injected at one bite is many times stronger

than the usual dose of antivenene can neutralize, and, moreover, that although Calmette's serum contains small quantities of bodies capable of immunizing the venoms of other serpents, the quantities are too small to render the serum valuable as an antidote against any poison other than that of cobra venom. The truth, however, remains that the results of Calmette and others in the use of antivenene have been encouraging, and whenever antivenene can be obtained it should be used in every case of snake bite. Antivenomous serum is prepared in hermetically sealed tubes, containing 10 c.c. In this state it will keep two years, but is said to deteriorate in hot climates. In the dried state it will keep indefinitely, and may be dissolved in sterile water for injection. Antivenene is much more efficacious when injected into a vein than when introduced subcutaneously. It should be used at once after the bite; the longer the delay the larger the quantity of antivenene necessary to neutralize the venom. Antivenene should of course not be used to the exclusion of other active treatment, as already described.

Poisoned Arrow Wounds

The poisons used by savage tribes on the points of their arrows and spears are of many kinds, and produce very varied symptoms. In some cases there is but a single active ingredient and a single definite group of symptoms. In others several poisonous ingredients are present, and the resulting symptoms are of a mixed character. In an Encyclopedia of Surgery (Kocher and Querain, Leipzig, 1903, vol. ii, p. 300) there is a short article on the subject by Th. Husemann. The following is based largely on the facts therein contained. In general it is to be borne in mind that, although the wounds produced by poisoned arrows are often of a trifling character, being in many instances mere punctures, the alkaloidal poisons introduced into the wound are so powerful, and so readily taken up by the circulation, that instant treatment offers the only prospect of saving life. If symptoms of poisoning are waited for, it is then, in most cases, too late. Immediate, firm ligature of the limb above the wound, removal of the arrow, free incision, irrigation of the cavity with water and mechanical cleansing may save life. In one of Stanley's Congo expeditions, a number of his people were wounded by poisoned arrows; all died, soon after receiving the wound, with tetanic spasms but one; his wound was sucked by a comrade, and his life thus saved. It is to be remembered that these poisons, being alkaloidal, are absorbed readily through the mucous membranes of the mouth, and that the mouth should be immediately cleansed after such suction is practiced. The arrow poisons of different parts of the world are many. According to the effects produced, they may be divided into seven groups. The preparations vary much in strength in different specimens.

I. **Heart Poisons.**—The majority of the arrow poisons used by Africans and Asiatics at the present time act like digitalin and helleborin, and cause death by sudden stoppage of the heart muscle. Observations on French soldiers in

the Soudan wounded by poisoned arrows of the Bambara tribe of savages, showed that death might occur in from eleven to thirteen minutes. Such poisons are, among others, the "Inee," "Kombe," "Wabain," "Antiacin." To the heart poisons belong also those used by the Choco Indians of New Granada, made from the skin secretions of a toadlike creature, Phyllobates melanorrhinus.

II. **Heart Poisons with an Action on the Nervous Centers.**—Various African arrow poisons contain one or several substances which act partly on the heart, causing spasm or paralysis of the heart muscle; also as powerful stimulants of reflex action in the cord, causing tetanic convulsions. In German southwest Africa, along the coast, the Owamba tribe use a poison known as "Echnja," prepared from a plant, "Adonium boehmianum," which produces this combination of symptoms, due to the presence of a glucoside, "Echnjin."

III. **Purely Tetanic Poisons.**—The Pongahns of Malacca and the natives of Borneo use the juice of various species of Upas to prepare a poison which produces general tetanic convulsions, and causes death in ten or fifteen minutes from asphyxia from tetanic contraction of the muscles of respiration.

IV. **Poisons Affecting the Respiration Center in the Medulla.**—Such are arrow poisons containing the aconite bases, aconitoxin and pseudo aconitin, made chiefly from the plant "Aconitum ferox," and used by people in eastern Asia.

V. **Poisons Causing General Paralytic Symptoms.**—Of these, "curare," used by South American Indian tribes, is the best known. It causes paralysis of the voluntary muscles throughout the body. Its symptoms are familiar to anyone who has ever worked in a physiological laboratory.

VI. **Septic Poisons.**—Putrid flesh, heart muscle, liver, etc., of animals dead of rattlesnake poison, or such material mixed with rattlesnake venom, were formerly used by the Indian tribes on the border between the United States and Mexico. Similar poisons are prepared by the African bushmen of the Kalahazi Desert from the body juices of the chrysalis of a beetle—Diamphidium simplex. These poisons do not act immediately, but produce a local hemorrhagic inflammation, with diarrhea, hemoglobinuria, collapse, and death in two or three days.

VII. **Irritating Poisons.**—The Moquis Indians of Arizona used a poison on their arrows made from the bodies of bumblebees. Other tribes have used the milky juice of Euphorbia arborescens. These are purely irritating substances, and produce merely an exceedingly painful wound, without any specific poisonous effects.

The Bites and Stings of Insects

Insects of various kinds, by stinging or biting, produce poisonous wounds. The results of such wounds are annoying, but not serious, unless a large number of bites are received. There are undoubted cases upon record of death.

following innumerable stings from wasps, bees, and hornets, and intoxicated persons have died after being exposed for hours to the bites of innumerable mosquitoes. The sting of the scorpion and the bite of the tarantula are especially poisonous, and much dreaded. The effects resemble in a mild form the bites of serpents; they are rarely, if ever, fatal to human beings. The symptoms caused by the stings of bees, hornets, and wasps consist of local pain of an aching or burning character. A tender red wheal forms almost at once, and remains for some hours. The sting is sometimes left in the wound, and may prolong the irritation. It may be searched for and extracted with the aid of a magnifying glass and a fine pair of forceps. Bedbugs, fleas, and body lice produce an urticarial eruption characterized by intense itching and burning, which usually subsides in a few hours, or, in sensitive persons, may recur, on mechanical irritation, for several days. Flea bites can usually be distinguished by the presence of a minute punctate hemorrhage in the skin, which can be seen in the center of the wheal. The bodies of those afflicted for long periods by body lice are covered with scratch marks, and after a time pigment is deposited in the skin, notably on the breast, the flanks, the abdomen, upper arm, and thighs. The appearance is characteristic.

The stings and bites of insects have acquired an entirely new and important interest during recent years, since observation and experiment have shown that certain infectious diseases are transmitted to man in this way. Among the insects capable of transmitting disease by bites are mosquitoes. The varieties of Anopheles transmit malaria; Stegomyia fasciata, yellow fever; Culex pipiens, filariasis. It is probable that dengue is also transmitted by a mosquito. Fleas are believed to transmit bubonic plague from one rat to another, or from rat to man, or from man to man. Ticks are believed to transmit certain febrile diseases in Asia and Africa; also probably the so-called "spotted fever" observed in the Bitter Root Valley of the Rocky Mountains. The bites of bedbugs are believed to play an important part in the transmission of relapsing fever. Lice may convey impetigo contagiosa. In addition to bites, flies and other insects transmit bacterial diseases by carrying the germs of typhoid fever, erysipelas, anthrax, etc., on their bodies, or in their alimentary canals, and depositing such germs in wounds, in food, water, etc.

GUNSHOT WOUNDS

Gunshot wounds are those produced by the discharge of firearms. For purposes of diagnostic description they may be divided into four groups: I. Those caused by modern military rifles and pistols of a caliber varying between 7 and 8 mm. II. Wounds produced by rifles and pistols firing a soft leaden bullet by means of a charge of ordinary black gunpowder and having a caliber varying from 0.22 inch to 0.45 inch or more. III. Wounds produced by shotguns loaded with many pellets of leaden shot of various sizes. IV. Wounds produced by artillery projectiles. It has been considered desirable to divide

gunshot wounds into these several classes, because the character of the wounds produced by these various weapons differ in certain important details. The

Fig. 2.—Gunshot Fracture of the Radius with Extensive Loss of Substance Produced by Soft Lead Rifle Bullet, Showing Fragments of Lead Embedded in the Tissues. The X-ray picture was taken nearly a year after the injury. An attempt to improve the condition by resection of the ulna and freshening the ends of the radius followed by suture of the bone was followed by nonunion in the radius and delayed union in the ulna. The functional result so long as the patient wore a supporting apparatus on the forearm was good. (Author's case.)

majority of gunshot wounds, however produced, partake of the character of punctured wounds, and most of them also of wounds of the contused and lacerated variety.

I. Wounds Produced by Modern Military Rifles and Pistols

The explosive used is one or other of the varieties of smokeless powder. The bullet is of very small diameter compared with its length, and consists usually of a core of hardened lead surrounded by a covering or jacket of a much harder material, consisting in many instances of a thin capsule of an alloy composed of copper and nickel or of copper, nickel, and steel. The point of the bullet is rounded or oval in shape. These weapons possess in their effects certain characters which distinguish them quite sharply from the old-fashioned rifles and pistols firing soft lead bullets. In the first place, the velocity of the projectile as it leaves the muzzle of the weapon is very great, and varies between 600 and 720 meters per second, as compared with 300 or 400 meters per second in the old-fashioned rifles firing a soft lead bullet with a charge of black powder. Moreover, the striking energy as compared with the older weapons is enormous. The range is also greatly increased. The effective range of the old-fashioned muzzle-loading rifle—of about 17 mm. caliber and a soft lead bullet—varied between 600 to 1,000 meters.

The Effective Range.—The range of the modern rifle is 3,000 or 4,000 meters, or even more. The trajectory of these modern rifles is also very flat, that is to say, the bullet travels so fast during the early seconds of its flight that it falls but little in going a long distance, hence much less allowance is

necessary for distance in aiming, and within certain limits hits are therefore much more frequent. Owing to the great momentum, the bullets at ordinary ranges seldom lodge within the body, but pass directly through in a straight line without reference to the structures encountered, whether soft parts or bones. Owing to the hardness of the bullet, it does not undergo deformity when striking bones, nor is it ordinarily deflected from its course.

Fig. 3*a*.

Fig. 3*b*.

Figs. 3*a* and 3*b*.—Fracture of the Astragalus Produced by a Thirty-eight Caliber Pistol Bullet with Lodgment. Antero-posterior and lateral views showing track of bullet through the bone and bullet *in situ*. (New York Hospital collection.)

Ricochet, and its Deforming Effect upon Bullets.—An exception to this rule occurs when, before striking the body, the bullet comes into contact with the ground or with a rock, when it may undergo deformity of any degree. The most common deformity noted is that the bullet is somewhat bent or flat-

tened at its point, or the deformity may be still greater; the bullet may be twisted quite out of shape, or the mantle or jacket may be split along one or more lines—commonly more or less parallel with the long axis of the bullet—and the leaden core may be thus exposed or even separated from its mantle,

FIG. 4*a*.

FIG. 4*b*.

FIGS. 4*a* and 4*b*.—GUNSHOT FRACTURE OF THE UPPER END OF THE RADIUS. Thirty-two caliber pistol-bullet showing fragments of lead and bullet slightly deformed lodged in the soft part above the elbow and in front of the humerus. (New York Hospital collection.)

and the axis of the bullet may assume any angle in reference to its line of flight; whereas under ordinary circumstances the two are parallel. Bullets thus deformed produce a different type of injury.

If, as in the case with sporting rifles and certain pistols, the mantle of the bullet is left incomplete in front, exposing the lead core to a greater or less extent, constituting what is known in sporting parlance as a "soft-nosed"

bullet, or if the mantle near the point of the bullet be sawed, filed, or split in such a manner that its continuity is destroyed or its strength near the point greatly impaired, then the bullet when it strikes a bone or even the soft parts may undergo great deformity. It may be extensively flattened near the tip —into the shape of a mushroom—or, indeed, broken up into many small fragments; and the injuries produced by such bullets are of greater severity than the wounds caused by the bullet with a complete mantle and undeformed.

Perforation and Lodgment.—The small calibered steel-mantled military bullet produces at ordinary ranges, as stated, perforating wounds. That is to say, the bullet passes entirely through the body, no matter in what situation or direction the wound may be received. This is of course true only up to a certain range, and after this range is passed—which varies, of course, for different regions of the body—a certain number of bullets will fail to pass completely through and lodge in the tissues. Lodgment of the bullet will also occur with considerable frequency at all ranges when the bullet strikes the ground or some hard object before producing the wound. At a range up to 1,600 or even 2,000 meters the bullet will usually perforate, unless it has previously struck the ground or impinges upon a dense large bone.

In discussing the diagnosis of wounds made by these bullets, it is necessary to consider the character of the tissues through which the bullet passes, and the range at which the shot was fired, that is to say—other things being equal —the velocity of the bullet. It has been found by practical experience that the effects of these bullets upon the tissues vary not only with the character of the tissue, but also with the range. Shots fired within the range of 500 meters may be regarded as short range, shots from 500 to 1,200 meters medium range, and from 1,200 meters upward, to the extreme range of the weapon, long range.

Effects upon Various Tissues.—In the ordinary soft tissues, the skin, the fat, fibrous tissues, fascia, muscles, thin and spongy bones, blood-vessels, nerves, the lungs, these bullets—at all ranges up to 2,000 meters, as stated by various observers—make a clean perforation through the body in a straight line. The openings where the bullet enters and where it makes its exit are often quite similar in character. They consist of small rounded openings of the size of or even smaller than the diameter of the bullet. At short ranges the wound of exit may be stellate, angular, or slitlike, and larger than the wound of entrance; this is not, however, constant. The tissues in the track of the bullet are pulpified, but there is very little laceration except in the immediate path of the missile. The path of the bullet through the tendons, fasciæ, and aponeuroses may be a small round hole or a mere slit. Blood-vessels and nerves may be cleanly perforated or partly or wholly divided; but they seldom escape injury by being pushed aside, as is the case with soft lead bullets fired at low velocities. If the bullet strikes the skin obliquely it may produce a slit of some length or an oval perforation of variable size. The spongy portions of

the long bones, if struck squarely, are frequently cleanly perforated, as though with a drill, very little lateral destructive effect being observed.

Explosive Effect.—At all but long ranges, where the velocity of the bullet is considerably diminished, there is observed an effect upon certain tissues and organs which has been characterized by the above title. This effect is observed in penetrating wounds of the skull; in the shafts of the long bones; in the solid glandular organs of the abdomen; in the hollow organs of the abdomen, when filled with fluid or saturated with fluid, and under certain other conditions to be noted. This so-called "explosive effect" is of a most destructive character and depends upon two causes:

The first cause is that which is well exemplified by the often-tried experiment of firing a rifle into an open barrel of water or into a tin can filled with water. If the barrel or can be empty, the bullet will pass through, making a clean perforation, but without other damage. If, however, the barrel or can be filled with water, even if open at the top, and the shot fired vertically downward, the barrel or can will be burst more or less extensively. Water is inelastic, and has no time to change its level and adapt itself to the new conditions of pressure; accordingly, it forces out the sides of and bursts the containing vessel. The same action takes place in wounds of the skull, etc.

Under these conditions the wound in the skull, for example, may be a small round hole as large as the diameter of the bullet. Upon the opposite side of the head, however, the skull will be burst outward, with extensive comminution of bone, and the projection of fragments of skull for a distance of several feet, with the production of a large ragged wound of exit; or the skull may not be actually burst into fragments, but yet be extensively fractured and fissured, the fissures running downward to the base. The liver may be very extensively lacerated and pulpified, the kidney the same, and the bladder, stomach, and intestines, if full of fluid, may be extensively burst and torn in all directions. If the bullet strike the hard unyielding shaft of a long bone, the bone may be pulpified for a large area around the point of impact, and fissures may extend in all directions up and down the shaft. The wound of exit in such cases may be very large and ragged.

The second cause for this explosive action is that the fragments of bone and other tissues thus set into violent commotion become secondary missiles, and cause laceration of the surrounding parts more or less extensive. Such wounds as these, if of the head, are usually instantly fatal, and do not come under treatment. If of the abdomen, they will usually be attended by such severe shock that little can be done for them. If of the extremities, the most varied lesions may be produced both in the bones and soft parts. The diagnosis of some of these varieties of wounds produced by the small-calibered rifle will be discussed under wounds of regions. If the range is greater than 1,000 meters these very destructive effects upon the brain, upon the large glandular organs of the abdomen, and upon organs containing fluid, gradually diminish as the velocity of the bullet decreases, and finally disappear. In a general way,

it may be said that the shorter the range, the more marked will be this explosive effect.

Hemorrhage in Gunshot Wounds.—In wounds which involve merely soft parts and do not penetrate any highly vascular organ, and injure no large blood-vessel, hemorrhage is usually slight or almost absent. If, however, a large arterial or venous trunk lies in the path of the bullet, hemorrhage of a serious or fatal character is rather more apt to occur than is the case with the large caliber soft lead bullet fired at low velocity, because, as already stated, if the shot be a direct one, the small-calibered bullet pushes nothing aside, but cuts a clean track in a straight line through the tissues. In cases where large vessels are wounded—such as the femoral, one of the larger arteries of the abdomen, or the carotid—it does not usually happen that the patient comes under surgical treatment at all if the wound be inflicted upon the battlefield. Wounds of the abdomen which injure the aorta, the vena cava, or one of the larger arteries of the mesentery, are peculiarly dangerous from hemorrhage, as also wounds of the thorax which injure one of the large vessels at the root of the lung. On the other hand, wounds of this very serious nature rarely come into the hands of the surgeon for treatment, and actual experience in time of war has shown that these bullets, if undeformed, may pass through the human body in the most varied manner, producing only temporary and comparatively slight injuries.

Topography of Bullet Wounds.—The position assumed by soldiers upon the firing line in battle is usually prone upon the ground. As a consequence, many wounds are produced which pass through the body from above downward or obliquely, and the wound canal is often very long, and may traverse the entire trunk, entering in the supraclavicular region or in the back, or, as often happens, passing through the shoulder first, or the upper extremity, and emerging from the buttock, or from the groin, or from the thigh, without producing a fatal injury. Wounds of the thorax also, which penetrate the lung, are frequently recovered from easily, and with little or no permanent disability. Wounds of the larger joints, such as the knee, the shoulder, and the ankle, often heal rapidly and without any permanent loss of function. Even wounds of the diaphragm—although attended at the time by shock, by rapid, shallow, and difficult respiration, and accompanied by some dyspnea, and by the accumulation of a moderate quantity of blood in the pleural cavity—often get well without any serious permanent results.

Aseptic Healing.—During the war in Cuba, during the fighting in the Philippines, during the war in South Africa, and in the Russian-Japanese War it was noted in hundreds of cases that such wounds were recovered from, with little or no treatment, except an external protective dressing, without permanent disability. These facts are to be accounted for upon several grounds. In the first place, a large proportion of the wounds are, as stated, perforating wounds. There has been, therefore, no occasion or excuse for the commonly dangerous and useless procedure of probing a wound with a dirty instrument

and unclean fingers to the detriment of the patient. Secondly, as already indicated, many of these wounds are either fatal before any medical aid is possible, or else involve no necessarily lethal injury. Thirdly, the shape and the small size of these bullets, and the fact that they perforate and do not lodge, diminishes the chances of infectious material in considerable quantity being carried into and remaining in the wound.

It has been found by experience that many of these wounds, if untreated, heal by primary union. The edges of the slightly contused orifices become brownish in color, dry, and are soon covered with a small adherent scab. Occasionally slight infection of one or other orifices takes place, but does not usually extend to the deeper portions of the wound. Careful inspection of the wound tracks often show that when the bullet has passed through the clothing small shreds of cloth and the like may be scattered along the course of the wound, but they do not appear to cause infection in many instances. Wounds of the skull through the scalp are usually found to contain fragments of hair and often particles of bone, which may be driven deeply into the brain or lie upon its surface or upon the dura. These fragments are often derived from the internal table, which is sometimes extensively splintered.

Straight Path of High-powered Bullets.—The diagnosis of the structures injured by these bullets is often much easier than was the case with the soft lead missile, for, in general, they pass through the body in a straight line, and the structures wounded can usually be inferred on anatomical grounds. If fractures exist, they will give the ordinary signs of fracture, unless the bone is merely perforated. Wounds of organs will give characteristic signs and symptoms. Wounds of the belly will be considered under the surgery of that region. When the range is very great, perforating wounds will cease to be the rule, and lodgment of the bullet will be more common. At very great ranges also the so-called "explosive effect" is absent. The bullet does not exercise the same destructive force laterally as occurs when the missile is moving at higher velocity. The prognosis, then, of such wounds when they involve the brain, the glandular organs of the abdomen, or the hollow abdominal viscera, is not so serious. The injuries come to resemble those produced by an undeformed leaden bullet moving at a low velocity.

Lodgment of the bullet may, of course, be inferred from the absence of a wound of exit. The practical importance of the continued presence of such a bullet in the tissues is not very great in the average case. It is only when the bullet causes pain, etc., by pressure on a nerve trunk or the wound has become infected and a suppurating tract remains in the tissues, with the bullet lying at the bottom thereof—as, for example, among the fragments of a fractured bone, or in the interior of the skull, with threatened abscess of the brain or symptoms of cerebral irritation—that the location of the bullet, and its subsequent extraction, become matters for the consideration of the surgeon. And even in these cases it is sometimes a question whether the operative removal of such a bullet is justifiable or desirable. The usual indications are,

however, when a bullet is lodged in an infected wound proper drainage of the wound, the extraction of foreign bodies, such as portions of clothing or fragments of dead bone, and removal of the bullet if fairly accessible.

Effects of Lodgment.—Long experience has shown that the mere presence of a portion of or the whole of a bullet in the tissues is seldom productive of deleterious effects. In some cases of bullet wound of the brain or of the spinal canal or in those cases where a bullet appears to be producing paralysis or irritation, by pressure upon a nerve trunk, the location of a bullet may, however, become a matter of practical importance. For locating such bullets no means hitherto devised compares favorably in simplicity, accuracy, and safety with the use of the X-rays. The well-known dangers of introducing a probe or other similar instrument into a fresh or ancient wound applies here with peculiar force. It is well known that the walls of a granulating wound are almost invulnerable to the inroads of the pyogenic bacteria, so long as the granulations are not mechanically injured. Probing a wound or introducing any instrument for diagnostic purposes—unless such an exploration is followed immediately by an operation which converts the wound canal into a simple and widely opened cavity—unavoidably injures the granulating surface, and renders infection with the pyogenic microbes not only possible, but probable, and it has come to be a well-recognized fact among surgeons that such infection frequently takes place, with serious, if not fatal, consequences to the unfortunate patient.

The X-rays, on the other hand, when used with intelligence, permit one to locate bullets with considerable accuracy, even when rather deeply placed in the tissues, and that without any especially elaborate apparatus. The proportion of lodged small-caliber bullets has been found in actual warfare to be unexpectedly high. Of 198 wounds from Mauser bullets coming under treatment in the Santiago campaign, there were 21 lodged bullets. Many of these bullets were found by X-ray examination undeformed or but slightly deformed. It is presumed that the absence of deformity depends rather upon the hardness of the bullet than upon the fact that the velocity of the bullet had been reduced by a very long flight. The nature of the ground over which the fighting was done indicated rather that the velocity of the bullets had been reduced by striking the limbs of trees or other objects. The methods of detecting and locating bullets and other foreign bodies are described in the chapter X-rays in Surgical Diagnosis.

Effects of Ricochet.—When military bullets are greatly deformed by ricochet and lodge in the tissues, they may or may not produce wounds showing great laceration of tissue. In many instances the wound will not vary in appearance from the ordinary small-caliber bullet wounds—notably if the bullet is merely blunted and strikes the tissues with its long axis perpendicular to the surface either point foremost or butt end foremost. If, on the other hand, the bullet after the ricochet assumes a rotation upon an axis transverse to its long axis, the wound of the skin may be of considerable size, and the

deeper tissues may be lacerated to a greater or less extent, and bones may also be fractured and comminuted more or less extensively. Under these conditions the wound may resemble such wounds as are made by the bullet from a shrapnel shell, or soft-lead bullet, or a shell fragment; and such wounds will, on account of the larger wound of entrance and the greater laceration of the tissues, be more likely to become infected from external sources. Nevertheless, experience shows that even in these wounds treatment by an occlusive dressing as soon as may be and noninterference with the deeper portions of the wound are attended by exceedingly good results, infection being the exception rather than the rule. Certain special indications for the location of lodged bullets will be spoken of under Regional Surgery. It has been found by experience that these deformed bullets usually pursue a straight course through the tissues.

Wounds Produced by High-powered Rifles of Small Caliber Firing a Soft-nosed Bullet.—A soft-nosed bullet is one in which the hard mantle is incomplete in front, the point being composed of soft lead, or in which the mantle is filed, sawed, or split at its point. Such bullets are commonly used in shooting large game, sometimes in fighting savage peoples, and occasionally by savage peoples themselves when firing at their enemies. They are variously known as the soft-nosed bullet, the Tweedie bullet, and the dumdum bullet. The injuries produced by high-powered rifles firing these bullets are much more severe than those caused by the ordinary full-mantled military rifle bullet.

Upon striking bone, or even the denser soft parts, these bullets undergo deformity of several types. The most common change in shape is that the soft portion of the bullet in front is flattened and spread into the shape of a mushroom; or upon striking hard bone the bullet may be disintegrated into many small pieces, each one of which becomes a missile and produces its own destructive effect. Fortunately, wounds from these bullets are rare in warfare, and occur for the most part as the result of accident, by the accidental discharge of sporting rifles of the high powered, small calibered type, or, as happens only too frequently, when an excited sportsman mistakes a companion or some other unfortunate individual for a wild animal.

Effects of Soft-nosed Bullets.—The wounds produced by these bullets upon the human body are of the most terribly destructive character. At short and moderate ranges they are perforating. At longer ranges the whole or a portion of the bullet may lodge. The wound of entrance in the skin does not differ from those wounds produced by the ordinary military bullet. But the expansion or disintegration of the bullet after entering the body produces wounds of the most destructive character. The shape of the wound is roughly a cone. The apex of the cone is at the point of entrance, and the base at the point of exit, or wherever the bullet ceases to produce its destructive effect.

The tissues in the track of such a bullet are churned up into a pulpified mass of entirely disintegrated tissues. The bones are also extensively fractured and comminuted; and, secondarily, lacerated wounds of variable size, extent,

and shape are produced by the fragments separated from the body of the missile. Such a wound, if of the head, the thorax, or the abdomen, produces so destructive an effect that an immediately or speedily fatal result is the rule. If of an extremity involving bone as well as soft parts, the disintegration of the tissues is commonly so great that no treatment other than amputation can be applied. If the wound involves merely the soft parts of an extremity, extensive laceration of muscles, vessels, nerves, and integument will be common. In certain instances, however, if these bullets strike merely the softer tissues, they may not become deformed, and may pass through a limb, producing the same effect as the harder military bullet.

Diagnosis.—The diagnosis of injuries produced by these bullets does not usually present any difficulties, the main factors being a small wound of entrance, a very large wound of exit, and very extensive laceration and pulpification of the tissues in the track of the bullet, whether such tissues be bones or soft parts. On account of the great destruction of tissue, infection of greater or less gravity is almost sure to occur.

Wounds Produced by Automatic Pistols: The Mauser Pistol, Caliber 7.63 Millimeters. The Luger Pistol, Caliber 7.65 Millimeters. The Colt Automatic Pistols, Caliber .32 and .38.—In 1897 Bruns conducted experiments with the Mauser pistol, and concluded that the effects of its bullet were identical with that of the military rifle at proportionately longer ranges. The following relations were found to exist: At 20 to 200 meters the effect of the Mauser pistol was the same as the effect of the military rifle at 1,000 to 2,000 meters respectively. In this connection I insert the results of certain experiments made by me with automatic pistols in order to determine the effects of smokeless powder at short ranges upon the skin, and incidentally to observe the effects of the bullets upon the tissues, in comparison with the old-fashioned black-powder revolver firing a soft-lead bullet and a small charge of black gunpowder.

The Effects upon the Skin of Black and of Smokeless Powder Fired at Short Ranges.—The effects upon the skin produced by the discharge of small arms loaded with black powder and fired at very short range have often been studied. The subject is of especial interest from a medico-legal point of view, and occasionally from the point of view of surgical diagnosis. Not all the grains of black powder in the charge are burned in the weapon unless the charge be unusually small; and the number of unburned or partly burned grains will increase with the size of the powder charge and the caliber of the weapon and diminish directly with the length of the barrel. These unburned or partly burned grains are propelled from the muzzle with considerable force for a distance of several feet. If these grains strike the human skin or the clothing, certain effects will be produced, which will vary according to the caliber of the weapon, the size of the powder charge, and the distance of the muzzle from the skin or the clothing, as the case may be. With a given weapon and a given charge of powder it may be possible to determine from the character of these effects

whether a shot has been fired within a certain distance or not. The important bearing of such data in certain cases of homicide or suicide is obvious; and evidence so derived has been of great use in many instances in the furtherance of justice.

The Effects Produced by Black Powder upon the Skin. Powder marks on the skin are in the nature of tattoo marks—that is to say, the grains of powder are driven into the substance of the skin, and leave black or bluish marks therein which are practically indelible. The area thus marked increases with the distance at which the shot was fired, whereas the number of grains embedded diminishes with the distance. Such tattooing occurs with ordinary black-powder revolvers at a distance of at least three or four feet; and such tattooing has been produced experimentally with a .32-caliber revolver at a distance of three feet. The hair of the scalp may be singed at a distance of seven or eight inches by such a revolver; clothing may be scorched at a similar distance; and at a distance of one foot or less linen may be set on fire.

A personal communication from Dr. Albert L. Hall, of Fulton, N. Y., who has conducted a large number of experiments with pistols loaded with black powder, contains some of the results of his observations. They are here quoted as of interest and value from a medico-legal point of view.

Human hair can be singed by the discharge of pistols loaded with black powder up to a distance of twenty inches, probably not more. Hair can be smoke-stained at about twice the singeing distance. Some of Dr. Hall's observations in detail were as follows:

A .30-caliber Colt's pistol loaded with 7 grains of black powder singed human hair up to 5½ inches. A .32-caliber Smith & Wesson pistol, 10 grains of black powder, 88 grains of lead, caused singeing at 7½ inches. A .44 automatic Colt's pistol, 40 grains of black powder, 217 grains of lead, caused singeing up to 17 inches, smoke-staining up to 3 feet. A .38 Colt's army pistol, singeing occurred up to 12 inches. With a .38 Smith & Wesson pistol, 15 grains of black powder, 146 grains of lead, hair was singed up to 10 inches.

The effects of black powder, then, are obvious, and within certain limits fairly definite.

The Effects Produced upon the Skin by the Discharge of Pistols Loaded with Smokeless Powder.—The effects of smokeless powder are very different. There are at present in the market several kinds of pistols using smokeless ammunition; it seems, therefore, not improbable that in the future a certain proportion of homicides and suicides will be committed with weapons using ammunition of this class. Smokeless powders have guncotton as a basis, to which is sometimes added a small amount of nitroglycerin, or some picric-acid compound, or one or more of a number of ingredients both organic and inorganic. The purpose of the additions is to modify the character of the ignition, or of the explosion, or to give the powder a distinctive color, or to make it waterproof. The grains of such powders are usually small in comparison with the grains of black powder, although not always. The explosion of black

powder gives on the average sixty-five per cent, by weight, of solid residue and thirty-five per cent of gases. Smokeless powders give, on the other hand, nearly seventy per cent of gases and thirty per cent of solid residue. Smokeless powder is at least twice as strong, weight for weight, as black powder, and some kinds are much stronger; accordingly, the amount of residue of smokeless powder driven from the gun is much less than that of black. The combustion of smokeless powder is, in other words, much more complete.

I experimented with five pistols—Colt's automatic pistol, caliber .32; Colt's automatic pistol, caliber .38; the Luger automatic pistol, caliber 7.65 mm.; the Mauser repeating pistol, caliber 7.63 mm. For comparison a black powder .32-caliber revolver was used, made by Hopkins & Allen, firing Smith & Wesson ammunition and black powder. For the purpose of testing the effects of the discharges upon the skin the body of a medium-sized man was procured. The cadaver was quite recent, the skin showed no signs of decomposition, the muscles were quite firm. Rigor mortis was absent. In addition to notes on the effects produced upon the skin, a few observations were made on the penetration of the different pistols, and a number of shots were fired at pieces of linen cloth and at a piece of woolen cloth. Some experiments were also made with a shotgun to determine the effects produced at different ranges. The shotgun was a 12-gauge Parker gun, what is known as a close-shooting gun.

Shot I.—Colt's automatic pistol, caliber .32; charge, 4 grains of Walsrode powder; bullet, weight, seventy-six grains, full cupro-nickel jacket; distance of muzzle of pistol from the skin, two inches. The shot was fired at the side of the head in front of the ear, skin covered with short hair. The hair was not singed. The skin was not burned. A few grains of a dark gray residue were found upon the hair and upon the skin over an area one inch in diameter surrounding the bullet wound. These grains were readily wiped off with a dry cloth, leaving no visible mark behind. The wound of entrance was a small circular orifice one sixteenth of an inch in diameter. There was no fraying or discoloration of the edges. The wound at the point of entrance in the skull was found to be a round hole through the bone about the diameter of the bullet. The wound of exit from the scalp upon the opposite side of the head, back of the ear, was a mere slit in the skin one fourth of an inch in length. The wound of exit from the skull was a round hole about the diameter of the bullet. No explosive effect was observed. The bullet struck, but failed to penetrate a barrel of sand used as a backing and was picked up slightly flattened at the point.

Shot II.—Colt's automatic pistol, caliber .38 of an inch; cupro-nickel jacket incomplete in front (what is known as a soft-nosed bullet); charge, 7 grains of Walsrode powder; weight of bullet, 130 grains. The shot was fired into the temporal region, at a distance of two inches. Wound of entrance was a round orifice in the skin one eighth of an inch in diameter. Edges of orifice were slightly frayed. There were a few faint grayish stains upon the skin surrounding the wound. These specks appeared to be embedded in the skin, and could not be removed with a wet cloth. The hole of entrance through the skull was round and about the diameter of the bullet. The wound of exit in the skin upon

the opposite side of the head was an irregular tear about one inch in length, with radiating slits along its border. Brain substance escaped freely from this orifice, as well as from the external auditory canal on the same side of the head. Palpation of the skull showed a comminuted fracture surrounding the wound of exit. The comminution of the skull extended over an area three inches in diameter in the temporal and parietal regions. There was also evidently present a fracture of the base of the skull. After leaving the head the bullet buried itself in a barrel of sand. The explosive effect of this shot was well marked.

Shot III.—For purposes of comparison, a shot was fired from a Hopkins & Allen revolver, caliber .32, ten grains black powder, Smith & Wesson ammunition,

Fig. 5.—Photograph of the Head of a Male Cadaver, Showing the Wounds of Entrance in the Scalp made by Pistols Held Close to but not in Contact with the Head. The shots Nos. 1, 2, and 3 are described in the text.

soft-lead bullet. The shot was fired into the temporal region with the muzzle of the pistol three inches from the scalp. The hair was singed. The scalp was burned and tattooed with powder grains, so that the skin was blackened over an area one and one half inches in diameter. The wound of entrance in the skin was one eighth of an inch in diameter, the edges were slightly contused and stained with lead. The hole in the skull was about the diameter of the bullet. The bullet lodged. The accompanying illustration is a picture of these three shots. From before backward: (1) .32, black powder; (2) .38, Colt, smokeless; (3) .32, Colt, smokeless.

Shot IV.—Luger automatic pistol; steel-jacketed bullet; jacket incomplete over a small circular area at the point of bullet where the lead interior is exposed; distance, three inches. Shot was fired into the cheek over malar bone backward, downward, and inward. No powder marks were upon the skin. Orifice of entrance was three sixteenths of an inch in diameter, and circular. Edges were slightly contused and white in color. No tearing of tissues nor explosive effect was observed. Bullet was extracted later undeformed.

Shot V.—Mauser automatic pistol; caliber 7.63 mm.; steel-jacketed bullet; distance of muzzle of pistol from skin three and one half inches. Shot was fired at outer aspect of upper third of right thigh. Powder stain was one inch in diameter, a grayish smudge without deposition of distinct grains. Wound of entrance was circular. Edges were slightly frayed and contused, white in color. Wound of exit on inner surface of limb was oval, three sixteenths of an inch in diameter, slightly ragged. There was wound of entrance on inner aspect of left thigh; wound of exit on opposite side the same. The bullet then passed through the distal phalanx of left thumb and entered a barrel of sand, penetrating a distance of one foot. Although the bullet passed through the center of both limbs, neither femur was fractured, nor was the bullet deformed.

Shot VI.—Mauser pistol; fired into upper third of right thigh at a distance of one foot; full-jacketed bullet. A few dark-colored specks or grains were present on the skin around the wound over an area three inches in diameter. These were readily wiped off with a dry cloth. The bullet caused a fracture of the right femur, and passed across the body above the perineum, passed through the pelvic bone and was found just beneath the skin above the left great trochanter. The bullet was slightly deformed.

Shot VII.—Hopkins & Allen revolver, black powder, .32 caliber, Smith & Wesson ammunition. Shot was fired at outer aspect of right thigh; distance, one foot. Skin was tattooed with powder marks too numerous to count over an area three and one half inches in diameter. Wound of entrance was circular, three sixteenths of an inch in diameter; edges stained with lead. Bullet lodged.

Inasmuch as the effects of smokeless powder upon the skin were found to be slight even at very close range, no experiments were made at a distance greater than one foot. The only shots producing stains which could not be wiped away were the Colt pistol, caliber .38, which produced a small and barely perceptible smudge upon the scalp at a distance of three inches, and the Mauser pistol, which produced a slightly more perceptible smudge at the same distance. At one foot none of the smokeless-powder pistols left any permanent powder marks upon the skin.

Photograph No. 2 is a picture of two shots in the thigh with a Mauser pistol at one foot and three and one half inches, respectively.

Photograph No. 3 is a picture intended to show the contrast between the effects of a .32 caliber revolver loaded with black powder and the Mauser pistol loaded with smokeless powder, each at a distance of one foot. The wounds were not wiped before the pictures were taken.

A number of shots were then fired with portions of a linen handkerchief

as a target. A piece of woolen cloth was then used, and then some squares of cardboard. The distances were three inches and one foot.

It is to be noted that the smokeless powders produced only very slight discoloration of the linen cloth even when fired at a distance of three inches.

FIG. 6 IS A PHOTOGRAPH, OVER WHICH THE LABEL NO. 2 HAS BEEN PASTED, SHOWING THE WOUNDS OF ENTRANCE OF TWO PISTOL BULLETS. To the right is shown the wound of entrance made by the Mauser automatic pistol at a distance of three and one-half inches from the skin of the outer surface of the right thigh (shot No. 5 as described in the text). The slight powder stain is readily distinguishable. On the left is the wound of entrance made by a bullet from the same pistol at a distance of one foot. The powder stains were so slight that they do not show in the photograph (shot No. 6 as described in the text).

Upon woolen cloth no effect was produced appreciable by the eye except a faint dark stain around the edge of the bullet hole. Some differences are to be noted between the effects produced on linen by the Colt's and the two German pistols. The Colt cartridges were loaded with a green granular powder, probably Walsrode. This powder produced a faint speckled discoloration which, when examined closely, was found to consist of a moderate number of minute black grains, adherent to but not deeply embedded among the fibers of the flax. No scorching effect could be detected. Under a microscope these grains resembled the fused masses of slag from a smelting furnace. The Mauser and Luger pistols were loaded with a powder which consisted of thin squares of a dark grayish-black color, evidently cut from a sheet of the mate-

rial from which the powder is made. I have been unable to learn the name of this powder, but it closely resembles the powder known as Ballistite in appearance, although the squares are smaller. These powders produced a faint grayish smudge upon the linen cloth at a distance of three inches. No distinct grains could be distinguished with the naked eye. Under the microscope the discoloration was seen to consist of numerous fine black angular grains embedded among the meshes of the flax fibers; the grains were about equal in

FIG. 7.—PHOTOGRAPH OF TWO SHOTS TO ILLUSTRATE THE DIFFERENCE IN THE EFFECTS UPON THE SKIN OF BLACK AND SMOKELESS POWDERS RESPECTIVELY. A paper label No. 3 has been pasted upon the skin. Upon the left a shot fired from a thirty-two caliber revolver charged with black powder, bullet of soft lead (shot No. 7 as described in the text). The tattoo marks and the staining of the edges of the wound of entrance with lead are plainly visible. Distance of muzzle from skin one foot. Upon the right a shot from a pistol loaded with smokeless powder at the same distance (Mauser). No powder marks are visible upon the skin.

diameter to a single fiber of flax, and their distribution was quite different from that noted with Walsrode powder; the grains were also much smaller and more numerous.

The changes produced in linen by black powder were quite different. At a distance of three inches the cloth was set on fire around the margin of the bullet hole. The cloth was scorched and discolored over an area more than three inches in diameter, and numerous powder-grain marks were scattered over the scorched area. Under the microscope these marks were found to be

due to the presence of a large amount of brownish-black granular material plastered on the surface of the flax bundles. The scorching of separate bundles of fibers was also quite evident.

When fired at paper the same differences were to be noted between black and smokeless powders. The black powder caused scorching of the paper at

FIG. 8.—PHOTOGRAPH OF GUNSHOT WOUND OF THE TEMPORAL REGION, SUICIDAL, WHAT IS KNOWN AS A CONTACT SHOT, PRODUCED BY A THIRTY-EIGHT CALIBER REVOLVER LOADED WITH BLACK POWDER. The laceration of the soft parts and the blackening of the wound edges produced by the black powder can be seen. The wound is behind the eye and near the tip of the middle finger of the individual who is raising the eyelid. An ether cone is over the patient's face. Before shooting himself in the head, the patient had shot himself in the abdomen, producing numerous perforations of the intestine. Since there were no cerebral symptoms at the time, I opened his abdomen and closed the perforations by suture. At the end of forty-eight hours, however, he became comatose and died of extensive laceration of the frontal lobes of the brain and intracranial hemorrhage. (Author's collection.)

very short distances (three inches), together with numerous marks of powder grains driven into the paper. At the distance of one foot the scorching was absent, but the powder grains were still very numerous and black. The smoke-

less powders fired at three inches caused slight smudging of the paper, and numerous little indentations of the surface of a gray color. The Mauser cartridges caused more discoloration of the paper and fewer indentations than the Colt. At a distance of one foot the Mauser produced scarcely any perceptible mark, and the Colt produced a few slight indentations and no discolorations.

Although these experiments are few in number and by no means complete, a few conclusions may, I think, be drawn from them.

1. Powder marks upon the skin and clothing produced by smokeless powder are much less distinct and definite than those caused by black powder.

2. With the weapons used in these experiments, such marks cease to be produced when the distance exceeds one foot and the shot is fired at the naked skin.

3. At a distance of three inches or less, powder marks may be present, but they will always be faint, and may in many instances be wiped away from the skin with a wet or dry cloth.

4. If the shot be fired at a part of the body covered with clothing, no powder marks at all will be found upon the skin. The clothing will never be scorched no matter how near the weapon is held. If the clothing be wool, no mark is likely to be detected upon it, even at the closest range. If the clothing be of linen, a faint mark may be found upon it if the weapon were held at a distance of three or four inches or less. If the distance much exceeded this, no mark would be produced. The evidence furnished by a microscopic examination of the pieces of linen appears to me to be quite interesting. It is evident that by this means it might, in certain instances, be possible to state with some positiveness that a certain kind of ammunition had or had not been used. Such a conclusion might be of the greatest importance from a medico-legal standpoint.

II. Wounds Produced by Rifles and Rifled Pistols Loaded with Black Powder and Soft-lead Bullets

These are different in several particulars from those caused by high-powered rifles and pistols loaded with smokeless powders and jacketed bullets. The velocity of the missiles is much lower and the penetration much less, hence a larger proportion of these bullets lodge. The bullets are soft, and are usually deformed or even broken up when they strike hard bone. Hence, great laceration of soft parts occurs, and at moderate ranges the injuries to the hard shafts of long bones, to the cranium, and to the solid, glandular, and hollow organs of the abdomen resemble the so-called explosive effects of the high-powered military rifle; indeed, they may be even much more destructive in the case of rifles of large caliber firing a heavy bullet. At longer ranges, when the velocity is much reduced, these effects diminish, and finally disappear.

Wounds by soft-lead rifle bullets at short and medium ranges are charac-

terized by a wound of entrance of about the diameter of the bullet itself, assuming that the shot is a direct one and does not strike the surface of the body obliquely. Whereas the track of the bullet through the tissues is usually much contused and much larger in diameter, and the wound of exit is frequently ragged and of a size which varies within wide limits, depending upon how much the bullet has been deformed or broken up by striking bone, by the velocity of the bullet, and by its size and weight. But in general it may be said that the wound of exit will be considerably larger and more ragged than the wound of entrance. At very long ranges, when the velocity of the bullet has been much reduced, and its rotation due to the rifling diminished, the wounds will be simpler in character and attended by far less destruction of tissue. In the thicker portions of the body at long ranges, the bullet will lodge or make a wound of exit but little if any larger than the wound of entrance. At low velocities, such bullets, if of small caliber, may even fail to cause fractures of bones, and may be more or less completely flattened against the harder portions of bones, or even against the skull. The wounds of the lungs or of the brain, or of the hollow organs of the abdomen, or of the glandular organs of the abdomen, will in many instances be simple perforations, without much laceration of the neighboring tissues (assuming that the range is great or the initial velocity low).

Wounds of blood-vessels produced by soft-lead bullets fired from rifles at short or medium range are often even more destructive than the wounds produced by the small-calibered high-powered bullet. They are also more frequent as the result of the greater size of the missile, and vary from complete or partial severance of the vessel to contusion and laceration of one or more of its coats, sometimes with the subsequent production of aneurism. Wounds of the nerves produced by soft-lead bullets vary much in the same way as do wounds of the blood-vessels, but contusions and partial lacerations of nerve trunks are more common than with the small-calibered bullets. At long ranges and at low velocities, blood-vessels and nerves may often be pushed aside by these bullets and escape actual division, suffering only contusion of greater or less severity.

Wounds produced by revolvers and pistols of small and moderate caliber are usually of a less complicated character than are wounds produced by rifle bullets. The charge of powder is small and the velocity of the bullet relatively low. In consequence the lateral destructive action is much less noticeable, and with the smaller calibers, .22 and .32, lodgment of the bullet is the rule rather than the exception in the thicker parts of the body. The fractures of the bones produced are generally accompanied by less comminution, and the explosive action noted in the case of large and more powerful weapons is rarely marked.

From the size and shape of soft-lead bullets, portions of the clothing are much more commonly carried into the depths of the wound than is the case with the small-calibered weapons. Owing to the larger size of soft-lead bullets, and especially owing to the greater size of the wounds of exit produced by soft-lead rifle bullets, infection of the wound is apt to occur. But even in

these wounds it has been noted in recent years that noninterference with the deeper portions of the wound is attended by greatly improved results in this respect. Unless the bullet has produced some injury which in itself demands operative interference, such as a wound of one of the hollow abdominal viscera, a wound of a blood-vessel or nerve, or an extensively comminuted compound fracture, the more nearly it can be treated as a subcutaneous injury, or rather the more nearly it can be made to resemble a subcutaneous injury, the less likely is infection to take place and the better the prognosis.

The diagnosis of bullet wounds of special regions and of special organs will be spoken of under the head of Regional Surgery.

III. Wounds Produced by Shotguns

These vary greatly in severity. The variations depend first upon the size of the shot constituting the load, and second upon the range at which the shot is fired. Buckshot, that is to say spherical soft-lead bullets, varying in weight from eight to twelve to the ounce, fired from a shotgun, produce wounds not very unlike those produced by small rifle or revolver bullets, except that, inasmuch as they do not rotate in an axis parallel with the line of flight, there is less lateral or explosive effect at all ranges. The ordinary load of a shotgun for such missiles varies in number from eight to twelve. At short ranges, as will be noted under the head of wounds produced by fine shot, such a load striking the body fairly produces the most terrible injuries. If they strike the head or thorax or the abdomen, the amount of destruction of tissue is very great, attended by severe shock, and such injuries are commonly rapidly or immediately fatal. If, on the other hand, the range is considerable, say one hundred yards or more, the character of the wound resembles quite closely that produced by a small revolver bullet traveling at similar velocity, and such bullets will often lodge in the thicker portions of the body. Wounds produced by small shot, such as are used in firing at upland game—No. 8, for example, containing 400–500 pellets in the charge—are of all degrees of severity, depending upon the range. The ordinary load for a shotgun of 12 gauge is one and one eighth ounce of such shot. For a shotgun of 10 gauge it is commonly one and one quarter ounce. At ranges less than and up to forty feet, such a load fired from an ordinary shotgun, such as is used for sporting purposes, has the effect when it strikes the body fairly, in part at least, of a single missile, and the destruction of the tissues is great.

In order to determine the effects of charges of small shot fired at the human body, I made a certain number of experiments upon the cadaver with various sizes of shot and with various loads of smokeless powder. The shotgun used was a 12-gauge Parker gun—what is known as a close-shooting gun. The subject was suspended by the head, in the erect posture, and all the shots but one were fired from in front. The thickness of the body through the abdomen from before backward was eight and one half inches.

Shot I.—Load, thirty-seven grains of Dupont's smokeless powder, said to be equivalent to three drachms of ordinary black powder; one and one eighth ounce of No. 1 shot. The gun was fired at the umbilical region, at a distance of eighteen feet. The spread of the shot was three and one half inches. In the center of the wound there was a ragged hole torn through the abdominal wall extending into the peritoneal cavity. There was a soft bulging tumor produced in the back nearly in the middle line, and about the size of the closed fist, and individual shot could be felt in and beneath the skin of the back over this area. The shot did not emerge through the skin of the back.

Shot II.—Same load; distance, thirty-five feet; shot was fired at epigastrium. Spread of shot was over an area seven inches in diameter. The shot wounds were

Fig. 9.—To Illustrate the Effects upon the Body of a Shotgun Loaded with Birdshot and Fired at Close Range. The label No. 4 has been pasted upon the abdominal wall. In the center, just to the right of the subject's navel, shot No. 1 as described in the text. Distance eighteen feet. To the right and to the left are seen the wounds produced at the same range with finer shot, as described in the text.

discrete, except near the center, where was a ragged hole one inch in diameter through the abdominal wall. In this hole there was embedded a felt powder wad. The shot did not emerge from the back.

Shot III.—Cartridge loaded with twenty-four grains of Ballistite powder, said to be equivalent to two and three fourth drachms of black powder; one and one eighth ounce of No. 9 shot; distance, eighteen feet. Shot was fired at the lower

part of the abdominal wall, to the left of the median line. Spread of the shot was six inches in diameter. There was a ragged hole through the abdominal wall one and one half inch in diameter, and a soft bulging tumor just above the crest of the ilium in the back.

Shot IV.—Load, thirty-nine grains of new Schultze powder, said to be equivalent to three drachms of black powder; one and one eighth ounce of No. 7½ shot

Fig. 10.—Underneath the Paper Label No. 5 is a Photograph of Shot No. 2 as Described in the Text. Range, thirty-five feet. To the left and above is shot No. 4 as described in the text. Range, eighteen feet.

—what is known as a pigeon load. The shot was fired at the thoracic wall near the nipple, at a distance of eighteen feet. There was a ragged hole one and one half inch in diameter, in the thoracic wall. A good many of the shot passed through the thorax, emerged from the back, and embedded themselves in the staves of a barrel placed behind the body.

Shot V.—This shot was fired through the thorax from behind at a distance of six feet. There were no powder marks upon the skin (smokeless powder). The

wound of entrance was but little larger than the caliber of the gun. The wound of exit in the back was a slit three inches in length. Nearly the entire charge passed through the thorax and embedded itself in the barrel behind, including a felt powder wad which was found wedged between two barrel hoops. Fragments of lung and heart tissue were plastered on the barrel and the wall of the room was extensively splattered with the same material.

At greater ranges the wounds produced by fine shot would be discrete, and the penetration and destruction of tissue would vary with the range, with the powder charge, with the size of the shot, with the thickness of the clothing if a clothed part of the body were struck, and also as the shot was a direct one or a ricochet. Generally speaking, at considerable ranges—a hundred feet or more—wounds produced by fine bird shot will be quite discrete and attended by very little serious injury, unless it happens that one of the shot enters the eye or happens to penetrate a thin portion of the skull, as noted under Injuries of the Head. Such wounds, if let alone, will rarely be attended by suppuration, and the pellets will generally remain embedded in the tissues without producing any serious disturbance. Search for them by operative measures is generally ill advised; if they cause trouble by pressure upon nerves, or if embedded in the eyeball or other delicate organ, they may be located by means of the X-rays by methods to be described.

IV. Wounds Produced by Artillery

These are of several different types. Wounds produced by large solid projectiles and by large fragments of exploding shells may be, and often are, immediately fatal. Decapitation, disembowelment, complete amputation of one or more extremities, and even the cutting of the human body in two, are common enough in time of war. In the days when the old-fashioned round mortar shells were used, the shells commonly burst into large fragments, and the wounds produced by such fragments were contused and lacerated wounds, often attended by immediate death, or by great laceration of tissue and severe shock. It frequently happened that, unless such wounds involved one of the extremities merely, the wounded died upon the field and did not come under surgical treatment. At the present time all the artillery used in warfare is rifled. The missiles are of three kinds:

First, there are the armor-piercing, or ordinary, shells, made of steel and containing a charge of powder, or sometimes of a high explosive, and intended to burst either at a given range or by impact. Such shells are fired at fortifications or at vessels of war, more or less completely protected by steel armor.

Second, there are shrapnel: shells of a similar shape, but thinner, containing a bursting charge of powder and a large number of round leaden bullets and discs of iron. Such shells are fired at bodies of troops at ranges varying from 1,000 to 6,000 or 8,000 yards. They are sometimes burst by a time

fuse and sometimes by impact. Shrapnel is effective up to from 1,000 to 4,000 meters; caliber, three inches. Shells fired from breech-loading rifled siege guns are effective at 8,000 and 10,000 meters.

The projectiles consisting of the jagged fragments of exploded shell and of the contained bullets derive their momentum partly from the original momentum of the projectile, cover a considerable area, conical in shape, and may be terribly destructive to groups or masses of troops at great ranges. The wounds produced are partly those of the jagged fragments of the shell itself and partly those of the contained hard-lead bullets. The fragments of shell produce contused and lacerated wounds of all degrees of severity; many of them are immediately or speedily fatal from laceration and destruction of important organs.

The bullet wounds do not vary much diagnostically from those produced by the small-calibered rifle bullets; but from the great ranges at which they are commonly fired they will often lodge in the thicker portions of the body rather than perforate. The differential diagnosis between such wounds and those produced by the military rifle can often be made by means of a radiograph, since the bullets are spherical and not cylindrical.

Third, there are the canister, consisting of a thin casing of metal containing a large number of leaden bullets, hardened and of considerable size; they are supposed to burst soon after leaving the muzzle of the cannon, and produce the effects of a shotgun, but on a greatly magnified scale. At short ranges the results are very destructive, and such wounds are often immediately fatal.

It would be supposed from the far greater efficiency of modern firearms that the number of fatalities in battle would be greatly increased, but it is to be remembered that troops at the present time seldom approach one another much nearer than 500 or 600 yards in the daytime, and experience has shown that the percentage of mortality has rather been diminished than increased. Troops no longer advance against the enemy in compact masses, but in scattered formation, and the soldiers are trained to take advantage of every kind of protection afforded by rocks, trees, and inequalities of the ground. It is true that the smaller size and weight of modern small-arm ammunition permits the soldier to carry from 100 to 200 rounds, but the number of hits is greatly diminished by the great ranges at which the shots must be fired. Imperfectly armed and partly civilized or savage peoples suffer a very high mortality when their ignorance or temerity leads them to charge upon trained troops armed with modern military rifles, but such conditions are exceptional.

HEMORRHAGE

Bleeding from Arteries.—Arterial blood, under normal conditions, is bright red in color, and escapes in jets projected sometimes to a distance of several feet. If the wound be deep, the appearance of a jet of blood may be absent. When a large artery is divided in a wound, the blood escapes with a hissing

sound similar to that caused by water escaping from a rubber hose or pipe. The division of an artery as large as the femoral or the brachial is fatal in a few moments unless checked artificially. The diagnosis of arterial bleeding may usually be made very readily by these signs. In the condition of syncope, when the heart acts feebly, the projection of the blood in jets may be absent; and in asphyxia, such as sometimes accompanies deep surgical anesthesia from chloroform or ether, the blood may be dark in color, even almost black. Pressure upon the trunk of the vessel between the bleeding point and the heart causes cessation of the hemorrhage, or at least marked diminution. If, however, the vessel be in a region like the face, where a rich anastomosis exists, bleeding may occur from both ends of a divided vessel, but that from the distal end will usually be continuous, and not in jets. The same condition obtains if the distal portion of the vessel in an extremity gives off a large arterial branch near the place of wounding. The anatomical situation of the wound is usually a good guide to the vessel wounded. In certain regions—the abdomen, the neck, and some other situations—the large number of arterial trunks may render this guide unreliable. Arterial bleeding in special regions—the abdomen, the interior of the skull, etc.—gives rise to special symptoms, to be spoken of under the head of Regional Surgery.

Bleeding from Veins.—Bleeding from veins is to be distinguished by the darker color of the blood, by its continuous flow—not in jets but in a steady stream—and by seeing the wounded or divided vein, if superficial. In wounds of veins of the extremities the bleeding may be stopped by slight pressure over the bleeding point. Pressure upon the vessel between the wound and the heart may increase the flow of blood. Pressure upon the vessel upon the distal side of the wound stops the bleeding, unless a large venous branch enters the proximal portion of the vein distal to any valve. Ordinarily, elevation of the limb and light pressure over the divided vein are sufficient to stop venous bleeding. In certain regions, notably in the neck and in the abdomen, valves in the veins are few or absent, and here venous bleeding may occur from both ends of the divided vessel, and may be severe, dangerous, or fatal. In the disease, varicose veins of the leg, the valves may be, and often are, incompetent, and bleeding may occur from both ends of the vessels. Under improper treatment maintenance of the erect position, pressure upon the proximal side of the venous trunk, etc., such bleeding may be dangerous, and even fatal.

Aspiration of Air into the Veins.—In the veins at the root of the neck aspiration by the thoracic respiratory movements may result in the entrance of air into the veins, with alarming or fatal symptoms. The veins of this region are large and rather firmly adherent to the surrounding tissues, and do not readily collapse when opened. The accident is a rare one. The signs are a hissing, gurgling sound heard in the wound, and sudden heart failure, with some symptoms of asphyxia, and death. Air enters the right side of the heart, and the contractions of the ventricle are unable to force the foamy mixture of air and blood through the lungs. Often the first symptoms noticed are

sudden heart failure and death. When only a little air enters a vein, no symptoms may be noticed, or the patient may suffer from moderate and sudden fall of blood-pressure and rapid and feeble heart action, which are gradually recovered from.

Parenchymatous and Capillary Bleeding.—Bleeding from the parenchyma of organs is a mixture of arterial and venous hemorrhage. The blood is of rather bright color, wells up from the entire raw surface, sometimes very rapidly, and such bleeding may be dangerous or even fatal. Some authors do not differentiate this variety of bleeding from capillary hemorrhage, in which again the blood is of rather bright color, and oozes from the entire raw surface. Dangerous bleeding from small vessels is common, especially under three pathological conditions: profound and prolonged jaundice, hemophilia, and splenic leukemia. Severe and fatal bleeding sometimes follows operations upon persons who have been deeply jaundiced for some time. The bleeding may occur at the time of the operation from all the tissues, and be continuous until death, or it may begin several days after the operation in a clean wound from some small vessel or vessels in the subcutaneous tissues, or from the peritoneum, or from both. This bleeding is often insidious, and is not noticed until the signs of intraperitoneal hemorrhage, or distention of the external wound, and staining of the dressings, and the weakened condition of the patient attract the surgeon's attention. It seems to depend upon a diminished power of coagulability of the blood, and is of bad prognostic significance.

Hemophilia.—Hemophilia is a disease transmitted through the females of a family to the males, among whom it generally occurs. The pathology of the disease is obscure. Many explanations of the condition have been offered; none are entirely satisfactory. The diagnosis is not difficult. There is usually from infancy or early boyhood a tendency to profuse, persistent, and recurrent bleeding from the skin, mucous membranes, and other tissues. Slight injuries, such as a needle prick, a blow upon the nose, a trifling wound, or the extraction of a tooth, are followed by continuous bleeding, which may resist all ordinary means to check it. The bleeding may cease, only to recur again when pressure is removed or a scab or clot is separated. This persistent bleeding from slight injuries suffices to establish the diagnosis. Ordinary surgical operations upon such individuals are dangerous, and even fatal.

Symptoms.—The signs and symptoms of excessive bleeding are to be observed after accidents, after severe surgical operations involving much loss of blood, after parturition, and after operations undertaken for the purpose of checking hemorrhage following accident or disease. These signs and symptoms are sometimes observed alone, but more commonly they are combined with the symptoms of shock, and not infrequently with the depressing effects of general anesthetics, notably chloroform, and sometimes ether. The signs and symptoms following serious loss of blood are as follows: The face, the mucous membranes, and the general cutaneous surface are pale; the extremities are cold; the pulse becomes rapid, feeble, and compressible; the patient suffers from

a feeling of extreme weakness; syncope may follow if the patient assumes the erect posture, or may occur spontaneously if the loss of blood continues; there are ringing in the ears, giddiness, often spots before the eyes, thirst, restlessness, and sometimes extreme irritability; the patient may toss and twist himself about incessantly; the features are drawn, and the expression of the face is anxious; there may be nausea and vomiting; there is air hunger and gasping for breath, due to anemia of the respiratory center of the medulla. Rapid, fatal bleeding is accompanied by intense dyspnea, by general convulsions, by unconsciousness, dilated pupils, and the involuntary evacuation of the contents of the bladder and rectum. A sign common to shock and severe bleeding is a marked fall of arterial blood-pressure. If the bleeding is not very great and is stopped, the arterial pressure soon rises to normal or nearly to normal.

The Riva Rocci Apparatus.—A special apparatus has been devised for the determination of the arterial blood-pressure during the performance of surgical operations. It consists of a hollow band or tube of rubber, which is made to surround the upper arm. The tube communicates on the one hand with a mercurial manometer, and on the other with a rubber hand bulb, by means of which the tube surrounding the arm may be inflated with air, and thus the tube may be made to constrict the arm more and more forcibly. A degree of constriction is finally reached such that the caliber of the brachial artery is obliterated, and with it the radial pulse. The height of the mercury in the manometer records the pressure necessary to stop the arterial blood current. Thus the amount of pressure over the brachial artery necessary to obliterate the radial pulse may be tested from time to time during the performance of an operation, and indications may be obtained in this manner for stimulation, for infusion of salt solution, or other measures intended to make up for the loss of blood.

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Blood Changes after Hemorrhage.—In addition to diminution of the blood-pressure, important changes occur in the composition of the blood as the result of severe hemorrhage. There is a rapid transfusion of the tissue fluids into the blood-vessels, and also a considerable flow of lymph.

The fluid which replaces the lost blood is necessarily of different composition from the plasma, and its addition to the circulation markedly affects the composition of the blood after hemorrhage. The blood when restored to its normal volume is found to be low in albumins, rich in salts, and poor in red cells. If the hemorrhage is rapid the alkalinity of the blood is diminished, while its coagulability is much increased. The hydremia affects principally the plasma, but Herz found the volume of the real red cells greatly increased after severe hemorrhage, indicating that they had absorbed much water.

In man, a distinct interval is required before the fluids have replaced the lost blood, and, according to Limbeck, thirty-five to forty minutes may elapse before a distinct reduction of red cells is observed after moderately severe hemorrhage. The changes in the number of red cells following hemorrhages are somewhat irregular, but a number of observers have shown that in man a single large hemorrhage

reduces the red cells in proportion considerably less than the effect upon the volume of the blood, beginning about one half hour after the operation, reaching a maximum effect in three to four days, and followed by a restoration to the normal number in nineteen to thirty-four days.

Healthy men recover rapidly from moderately severe hemorrhages. Small and repeated hemorrhages, on the other hand, have led to some of the most severe forms of anemia, the prevailing feature being the diminished quantity of hemoglobin. Very extensive observations have been made on the condition of the blood after hemorrhages by Bierfreund, in the clinic of Prof. v. Mikulicz. He found that the regeneration of the blood is most rapid in male subjects between the ages of twenty and forty years. A loss amounting to five per cent of hemoglobin was found to lengthen the period of regeneration two to eight days. The minimum percentage of hemoglobin was reached, after a loss of ten to fifteen per cent, in three days and a half; after twenty-six per cent, in 9.6 days; in women usually one day later than with men. (Adapted from Ewing, "Clinical Pathology of the Blood.")

Certain Effects of Severe Hemorrhage.—It is generally accepted that if the amount of hemoglobin is less than thirty per cent it is unwise to perform any serious surgical operation. There are, however, exceptions to this rule, and patients whose hemoglobin was reduced to twenty per cent have survived serious operations. The effects of the loss of blood vary much in different individuals. If the blood is lost slowly and gradually, the effects are less dangerous than though one single large hemorrhage has occurred of equal amount. Generally speaking, a loss of one quarter of the total volume of blood constitutes a very serious hemorrhage, but instances are recorded in which half the percentage of red cells has been lost, and yet recovery has taken place. In dogs it has been found that a loss of blood equivalent to five per cent of the body weight is always fatal.

Methods of Estimating the Quantity of Hemoglobin in the Blood.—The percentage of the loss of hemoglobin may be determined by means of the instrument known as the hemoglobinometer, in which the color of the blood, diluted to a certain definite proportion, is compared with the color of a wedge-shaped piece of red glass. Miescher's modification of Fleischl's hemoglobinometer is the instrument commonly used, and one which gives fairly accurate results. The blood is drawn from a small wound into a graduated pipette, and mixed with 200 or 300 or 400 parts of water, and the color of this mixture, placed in a cell of a certain depth, is compared with the color of a wedge of red glass, both being viewed against a white background. A fairly satisfactory method of estimating the hemoglobin is by comparing the color of a piece of white bibulous paper dipped in the blood to be tested with a standardized series of colored slips of paper mounted on a card. Each slip represents accurately the color of a blood solution containing a definite percentage of hemoglobin. The test is sufficiently accurate for practical purposes. (The Tallqvist Scale.)

The comparison must be made by daylight. The most satisfactory instru-

ment for estimating the amount of hemoglobin is Dare's Hemoglobinometer, or the Fleischl-Miescher. The undiluted blood is drawn by capillary attraction between two glass plates, which form a chamber of definite thickness.

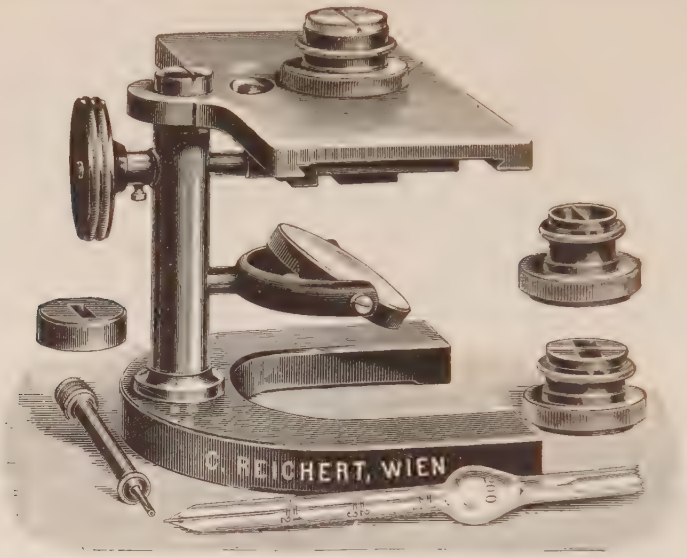


Fig. 11.—Fleischl-Miescher Hemoglobinometer. (Wood.)

The color is then compared with the color plate of the instrument. When the colors are matched the reading of a suitable scale indicates the percentage of hemoglobin in the blood.

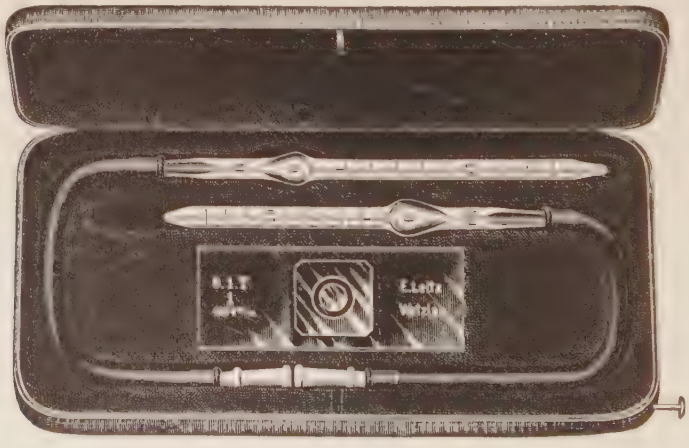


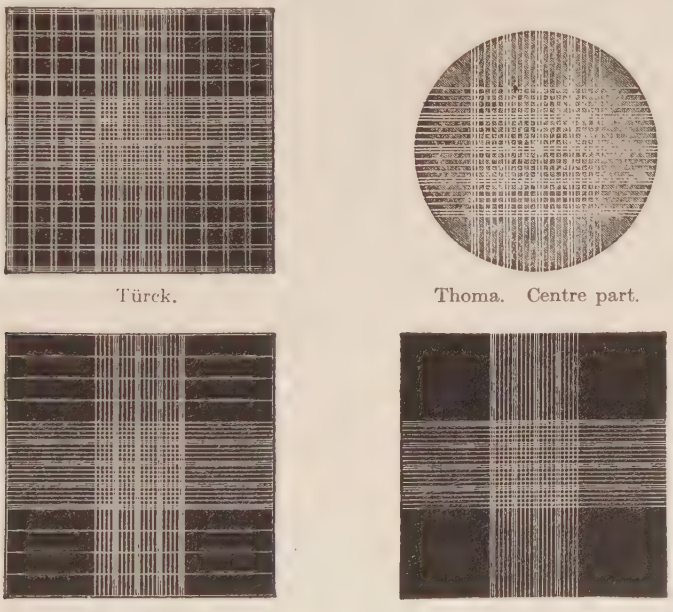
Fig. 12.—Hematocytometer. (Wood.)

Estimation of the Red Cells.—The estimation of the actual number of red cells contained in a specimen of blood is a somewhat complicated procedure. A description of it, and of the method of its use, is quoted from Ewing, "Clinical Pathology of the Blood," p. 35 *et seq.*

The Hematocytometer.—The instrument now in use for counting blood cells is that of Thoma, who combined and improved several features of instruments previously devised by Hayem, Gowers, and Malassez. This apparatus consists of a mixing pipette and a counting-chamber.

(*a*) *The pipette* is a capillary tube graduated in ten equal divisions, surmounted by a bulb of exactly one hundred times the capacity of the tube, and to which is attached a rubber tube and mouthpiece (Fig. 12). When the tube is filled with blood up to the mark 1, and this is mixed with a diluting fluid sucked up to the mark 101, a specimen of blood is obtained in the dilution of 1:100. By filling only one half the tube with blood, up to the mark 0.5, the subsequent dilution is in the proportion of 1:200. The bulb contains a glass ball to facilitate the mixing of the blood.

(*b*) *The counting-chamber* is constructed so as to secure a layer of diluted blood $\frac{1}{10}$ mm. in depth over a certain square area. On a thick glass slide is



Türck. Thoma. Centre part.

Zappert-Ewing. Thoma.

Fig. 13.—Blood-counting Chambers. (Ewing.)

cemented a thinner glass plate, the central portion of which is cut out. In this central area is cemented a circular glass shelf, the surface of which is exactly $\frac{1}{10}$ mm. lower than the surface of the glass plate. When a drop of diluted blood is placed on the shelf and covered with a cover-glass, a layer of fluid is secured, which is exactly $\frac{1}{10}$ mm. deep. Between the edge of the shelf and the surrounding plate is a moat into which the blood may run, but if the fluid should run over the moat and beneath the cover-glass, the latter will be elevated and the resulting layer of fluid will be more than $\frac{1}{10}$ mm. deep. The shelf is accurately ruled, as shown in Fig. 13.

The entire ruled area is 9 sq. mm., but only the central square millimeter is used in counting red cells, the others being required in counting leucocytes. It

will be seen that this central square millimeter is subdivided into 100 small squares (16 blocks of 25 each), so that each small square is $\frac{1}{400}$ sq. mm. Beginning at the lower left-hand corner of this area, it will be seen that every fifth square, above and to the right, is subdivided by an extra line, which is added merely to assist in counting the squares. The outlying square millimeters are variously ruled. The above description applies only to the so-called "Zappert" chamber, which should always be secured, preferably of Zeiss's manufacture. The older chambers cannot well be used for counting leucocytes.

Diluting Fluids.—Of the various diluting fluids, *Toisson's Mixture* is to be recommended:

Sodium sulphate	8.00 gms.
Sodium chloride	1.00 gm.
Glycerin pur.	30.00 gms.
Aq. dest.	160.00 "
Methyl violet	0.25 gm.

This fluid keeps well, stains the leucocytes, and is of high specific gravity, so that the red cells settle from it slowly.

When counting leucocytes only, one may use with advantage a 0.6 per cent solution of sodium chloride tinged with gentian violet (about one drop of saturated alcoholic solution gentian violet to 50 c.c. of salt solution). This fluid, while readily prepared, does not keep well, and the red corpuscles settle from it so rapidly that it ought not to be used in counting these cells. It permits, however, of the identification of eosinophile cells and of certain degenerative changes in leucocytes.

A reliable fluid for diluting and permanently preserving blood is found in *Hayem's Mixture*:

Hydrarg. bichlor.	0.5 gm.
Sod. sulphat.	5.0 gms.
Sod. chlor.	1.0 gm.
Aq. dest.	200.0 gms.

Directions for Using the Hematocytometer.—(*a*) *Filling the Pipette.*—The finger tip of the patient is cleansed with soap and water, dried with alcohol, and freely punctured with a needle or a specially prepared acne lancet. Using very gentle pressure only, a compact drop of blood is then expressed and the capillary tube is filled to the mark 1 or 0.5. In doing this the pipette must be held between the thumb and forefinger and the hand steadied against the hand of the patient. In well-constructed pipettes the column of blood is easily controlled, and after filling the end of the tube may be cleansed of adherent blood. The diluting fluid is then sucked up to the mark 101, taking care that no blood runs out of the tube when it is immersed in the fluid. The specimen is then thoroughly mixed by shaking.

(*b*) *Filling the Counting-chamber.*—The counting-chamber and cover-glass are thoroughly dried and freed from particles of dust. One or two drops of diluted blood are first forced from the pipette, and the third drop, the size of which can be learned only by experience, is deposited on the central shelf. The cover-glass is

then immediately adjusted, slipping one corner under the forefinger of the left hand and controlling the opposite corner with the second finger of the right hand, and lowering the glass slowly so as not to include air bubbles. Without raising the fingers, now quickly cover the other corners with the forefinger of the right and second finger of the left hand, and press the cover-glass firmly into position. If the application is successful and no dust particles have intervened, *Newton's color rings* will appear beneath the cover-glass. The formation and permanency of these rings may be facilitated by breathing *very gently* on the specimen before applying the cover-glass.

The specimen should now be held up to the light and examined closely to see that the red cells are evenly distributed. An uneven distribution is readily detected by the naked eye. After settling a few moments, the specimen is ready for counting.

The rapid and successful adjustment of the cover-glass is the most important detail in the process of counting blood cells. The cover-glass must be *rapidly* adjusted, because from the moment the drop is placed upon the shelf there is a rain of cells upon the ruled area out of a layer of fluid which is more than $\frac{1}{10}$ mm. deep.

The specimen must be discarded:

if Newton's rings do not appear;
if any air bubbles are inclosed;
if the fluid runs underneath the cover-glass;
if the shelf is not well covered by fluid;
if, on inspection, the cells are found unequally distributed.

(*c*) *Counting the Red Cells.*—The specimen proving satisfactory, the count may begin as soon as the cells have settled. Zeiss, D., Leitz, No. 7, Reichert's or Bausch and Lomb, $\frac{1}{6}$, are the lenses best suited for this purpose, and a good mechanical stage is necessary for accurate work. Locate in the field the lower left-hand block of 25 small squares, begin at the lower and left square and passing to the right count all the cells lying in the first five squares. The fifth square will be found subdivided. In each square count all the cells lying on the *lower* and *left* side lines, leaving to be counted with the adjacent squares all the squares lying on the lines *above* and to the *right*. Proceed in this way until at least four blocks of 25 small squares and at least 1,000 cells are enumerated. The more squares counted over, the greater the accuracy, and when slight variations are to be demonstrated the entire square millimeter must be covered. If the cells now appear to be unevenly distributed, the specimen should be discarded and another prepared after thoroughly shaking the pipette.

(*d*) *Computation.*—Suppose the 1,280 cells are enumerated in 100 small squares—i. e., in one fourth of the square millimeter. This number multiplied by 4 gives the number lying over 1 sq. mm. But the depth of the fluid is only $\frac{1}{10}$ mm., so that we multiply again by 10 to get the number of cells in one *cubic* millimeter of fluid. Finally, we must multiply by 100 because the blood is *diluted* in the proportion of 1 : 100.

In short, after counting over 100 small squares the result is multiplied by *4,000* to give the number of cells per cubic millimeter ($4 \times 10 \times 100 = 4{,}000$).

If the capillary tube was originally filled to the mark 0.5, the dilution is 1 : 200, and the multiplier *8,000*. If 400 squares are counted over, the multiplier is *1,000*.

(*e*) *Sources of Error in the Hematocytometer.*—1. *In Securing the Drop of Blood.*—When much pressure is employed in expressing the drop of blood, tissue fluids are squeezed out with the blood and the number of red cells is reduced. Reinert found a reduction of 722,000 from this cause, which is especially potent in cases of dropsy and of severe anemia.

When the finger is cold, the circulation poor, or local stasis is produced, as by a ligature, the red cells are increased in number. To avoid errors of this class, the circulation in the hand should be as active as possible, the finger warm, and the puncture liberal enough to permit the flow of blood with little pressure applied at some distance from the puncture. Unless these conditions can be secured, it is hardly worth while to count the blood cells.

2. *In diluting the blood and in transferring it to the counting-chamber* there are numerous, plainly evident, sources of error, such as the inaccurate filling of the capillary tube, the entrance of air with the blood column, the failure to cleanse the tip of adherent blood, the escape of blood into the diluting fluid, the overfilling of the bulb with diluting fluid, the inadequate mixture of the blood, the failure to discharge one or two drops before applying one to the shelf, the use of thin cover-glasses, and, above all, delay and inaccuracy in adjusting the cover-glass. A little experience and constant care serve to eliminate all these difficulties.

3. *In the Construction and Condition of the Apparatus.*—The tendency to favor the Zeiss instruments is still probably well founded, although Leitz and Reichert are now making very excellent pipettes after Grawitz's model. Aside from inaccuracies in the graduation of the pipette and construction and ruling of the counting-chamber, which are now reduced to a minimum, some pipettes are still on sale which are too short, their caliber is too large and is narrowed at the point so that tubes cannot be cleaned, they require too much blood, and the short arm is so small that the mark 101 comes too close to the bulb. Accurate work cannot be performed with such instruments. The worker is at present advised to insist on having Grawitz's pipette made by Zeiss, Leitz, or Reichert.

Many close observers find that their pipettes vary with the temperature. While accurate information on this point is not at hand, it is just as well to avoid extremes of temperature in making the tests and in cleaning the instrument. It has been suggested that the polycythemia of high altitudes is partly referable to variations in the hematocytometer due to changes in atmospheric pressure, but this suspicion has not been confirmed.

The condition of the pipette is of prime importance. Absolute dryness of the tube and bulb is essential. The collection of minute water drops in the tube and bulb is responsible for many of the shadow corpuscles sometimes seen in the counting-chamber.

Every few weeks a pipette should be cleaned out with concentrated nitric acid.

(*f*) *Cleaning the Apparatus.*—After using the pipette the rubber tube may be transferred to the long arm and the remaining fluid expelled. The tube should then be cleaned thoroughly with water, then with alcohol and ether, or, better, with pure ether. It must be thoroughly dried before using again. The counting-chamber must be cleaned with *water only, as alcohol and ether dissolve the cement under the shelf and plate.*

(*g*) *The Limit of Error with the Hematocytometer.*—Lyon, Thoma (and Reinert), counting an average of 1,141 cells in 100 squares with a dilution of 1 : 200,

found an average error of 1.82 per cent in 24 preparations of the same specimen, and in another case, counting an average of 934 cells in 100 squares, 1:200 dilution, an average variation of 2.71 per cent in 12 preparations of the same specimen (Limbeck). These results in the hands of experts using special care indicate that a variation of 150,000 cells (three per cent) cannot be accepted as of any significance. More accurate data are, however, seldom required by the clinician.

Leucocytosis.—An increase in the number of white cells in the blood has been repeatedly observed after considerable bleeding, but it is of no special diagnostic significance.

SHOCK

Shock is a condition of depression of the vital forces following injuries—physical shock, sometimes surgical shock. A somewhat similar condition may be caused by terror or other sudden mental impressions of a distressing or horrible character—psychic shock. Shock may follow slight or grave injuries. The severity, duration, and outcome of shock depends largely upon the gravity of the injury itself, and partly, also, upon the physical and mental condition of the individual at the time the injury is received. In shock following slight injuries, notably when the psychic element predominates over the physical, the symptoms may be confined to an evanescent feeling of faintness of short duration, or to actual syncope, recovered from quickly or slowly, but completely, usually in seconds or minutes. The symptoms of shock may be entirely absent even in severe injuries, even those which are subsequently fatal, when the injury is received during states of intense mental preoccupation and exhilaration, and may be very marked even after slight injuries, when the general nervous system is depressed from terror, extreme physical fatigue, or other depressing factors. In battle, or even in times of peace, when the individual is stimulated by enthusiasm or anger or other mental preoccupation, the most severe injuries may be unattended by the symptoms of shock, either local or general. The individual may, indeed, be quite unconscious that any injury has been received. Acts requiring extreme muscular exertion and courage may be performed after the receipt of severe and even dangerous wounds, and the individual may only be conscious that he is injured by seeing or feeling the flow of blood or from faintness due to hemorrhage.

Signs and Symptoms of Shock.—Shock occurs, as will be noted, very commonly after injuries of the abdominal contents and after serious injuries of the contents of the thorax or of the cranium, as well as after serious injuries of other parts of the body. The condition appears to be due largely to mechanical irritation of the peripheral nerves, with reflex, partial or complete, paralysis of the vasomotor centers of the medulla. The normal tone of the arteries throughout the body is lost; there is a sudden and decided fall of blood-pressure. The heart acts feebly and irregularly, and the blood tends to accumulate in the large veins, notably in the veins of the abdomen; while the lungs, the

brain, and the skin are anemic. The right side of the heart is sometimes distended with blood.

The appearance of an individual suffering from shock is fairly characteristic. The skin and the mucous membranes are pale. The surface of the body is cold and bathed in a clammy sweat. The features are pinched. The expression of the eyes is dull, and the pupils are often dilated and respond but slowly to light. The pulse is feeble, compressible, and irregular, sometimes slow and sometimes rapid. Respiration is irregular and often sighing, shallow respirations alternate with deep sighs. Cerebration is imperfect. These patients answer questions in a dull and stupid manner, and do not realize the gravity of their condition. Frequently they suffer but little pain in spite of the most severe injuries. The body temperature is often subnormal. There may be nausea and vomiting. The condition of shock may last for some minutes or for many hours. (It is stated by some authors that the symptoms of shock may not appear for many hours after the injury or surgical operation, as the case may be. This condition has sometimes been designated as delayed shock. It seems probable to me that in at least many instances this condition is really due to an acute septicemia or to hemorrhage or to a combination of these conditions.) If the patient is to survive, the symptoms gradually improve either with or without treatment. The action of the heart and the breathing slowly return to normal. The skin becomes warm, etc. If the condition is a fatal one, the patients gradually sink into a condition of unconsciousness and die from heart failure.

Shock and Hemorrhage.—Following accidents, surgical operations, and the administration of general anesthetics, the condition of shock is frequently combined with the depression caused by loss of blood and the administration of large doses of ether or chloroform, as the case may be. In cases of accident, hemorrhage and shock are frequently combined, and it may not be easy to distinguish which of the two conditions is the predominant factor. In cases of injury of the abdomen, for example, it may be of great consequence to know whether the patient is suffering from shock or from hemorrhage or from a combination of both conditions. For upon the decision of this question the surgeon must often be guided as to whether he should open the abdomen immediately or leave the patient alone, at least for a time. If the condition has endured for some little time, an examination of the blood for its content of hemoglobin may be a valuable aid. If the percentage of hemoglobin in the blood is notably diminished, it is at least probable that the symptoms are in part due to loss of blood. If the symptoms have occurred immediately after the injury and slowly grow better under appropriate treatment, it is probable that shock is an important factor in the condition. If the patients have been in fair condition after the injury, and the symptoms have only come on gradually and are of a character which are described under the head of Hemorrhage, it is probable that loss of blood is the cause of the condition.

Local Shock.—It has been repeatedly noticed that gunshot wounds are attended by more or less complete paralysis, both motor and sensory, of the injured part, which may last for hours or days. This condition gradually passes away, and is followed by a return of motion and sensation, assuming that no large nerve trunk is injured, no large blood-vessel divided, no body cavity opened, nor any other essentially serious complication has occurred.

CHAPTER II

THE DIAGNOSIS OF THE DISEASES CAUSED BY THE PUS-PRODUCING BACTERIA

VARIETIES OF PUS-PRODUCING ORGANISMS

Before describing in detail the local and general disturbances produced in the human body by the pyogenic bacteria, it will be desirable to consider: (1) Some of the general and special characters of these organisms; (2) their occurrence in the body under normal conditions; (3) the avenues whereby they gain an entrance to the body.

In speaking of certain specific infectious diseases (Chapter III) we have noted that the effects produced by inoculation with tetanus bacilli, etc., are fairly constant, and that following such inoculation we may predict with certainty the character of the local and general symptoms which are to follow. Such is not the case with the pyogenic bacteria; their effects are very varied. A great variety of disturbances may be produced by the same organism under different conditions, and several kinds of bacteria are capable of producing the same pathological changes. For example, any one of several varieties may produce purulent, serous, or fibrinous inflammations, and may, under suitable conditions, cause such varied lesions as furuncle, osteomyelitis, purulent peritonitis, septicemia, or pyemia. Although a good many varieties of bacteria may cause suppuration under special conditions, yet there are certain ones which, on account of their regular association with these processes, are to be regarded as the pus-producing organisms *par excellence*. These are: (1) Staphyloccus pyogenes aureus; (2) Staphylococcus pyogenes albus; (3) Staphylococcus pyogenes citreus; (4) Staphylococcus pyogenes cereus albus and flavus; (5) Streptococcus pyogenes; (6) Varieties of Streptococcus pyogenes, also Bacillus pyocyaneus; (7) Micrococcus tetragenus; (8) Bacillus coli communis.

Staphylococcus pyogenes aureus is a micrococcus of irregular size, of an average diameter of 0.9 μ, arranged irregularly in masses.

This bacterium, which is nonmotile, grows on gelatin plates in minute colonies, apparent under a low power of the microscope after twenty-four hours, granulated on the surface, and of a brownish color. The colonies gradually become visible to the naked eye as whitish-yellow points, which later become more distinctly golden yellow. Liquefaction of the gelatin occurs around them, and a

funnel-shaped depression appears, at the bottom of which are the colonies. In needle cultures in gelatin the line of development appears along the needle track on the day after inoculation, and on the second or third day the beginning of liquefaction may be noted at the upper portion. The liquefaction progresses slowly at the lower portion of the culture, more rapidly at the upper part; as it increases, the main portion of the colony falls to the bottom as a flocculent deposit which takes on a golden-yellow color, while the liquefied portion remains turbid; finally, in the course of from one to two weeks the gelatin becomes entirely liquefied out to the wall of the tube. On agar the colonies develop along the needle track as an abundant, moist, shining growth, which is well marked after twenty-four hours at the temperature of the body. It later takes on the golden-yellow color, which may be well marked at the end of forty-eight hours. On potato it grows well, producing an abundant layer that also assumes a golden-yellow color. In bouillon it produces a uniform cloudiness, which later sinks to the bottom, with a brownish-yellow color. It coagulates milk, produces an acid reaction in the various media, does not produce spores, although it retains its vitality in old cultures for a considerable length of time, and requires rather a higher temperature for its destruction than most nonspore-bearing bacteria (according to Lubbert, needing a temperature of 80° C. for half an hour). It stains readily with any of the anilin colors, and by Gram's method.

Pathogenic Properties.—Injections of small amounts of pure culture are usually not followed by any results; but large amounts, or intravenous or intra-abdominal injections, are usually followed by fatal results in rabbits or guinea pigs in a few days, with minute abscess formation in the kidneys especially.

The STAPHYLOCOCCUS PYOGENES ALBUS is a micrococcus less virulent than the preceding, whose characteristics are precisely the same with the exception that its colonies are white and not colored.

The Staphylococcus epidermis albus of Welch is probably but a variety of the preceding, occurring in the deeper layers of the skin.

A third micrococcus of pus, much less common than either of these two, is the STAPHYLOCOCCUS PYOGENES CITREUS, differing from the others in that its colonies are of a lemon yellow, and the fact that its pathogenic properties are very slight.

The STAPHYLOCOCCUS CEREUS ALBUS and the STAPHYLOCOCCUS CEREUS FLAVUS are of practically no importance. They are found occasionally in suppurative processes. They do not liquefy gelatin; the one produces a white waxy growth upon ordinary media, while the other produces a yellow waxy growth. They have not been shown to have any special pathogenic properties.

The STREPTOCOCCUS PYOGENES is a coccus of a somewhat larger average size than the staphylococcus, being about 1 μ in diameter, occurring in chains which may be made up of a large or of a small number of cells. Sometimes there is the appearance of a chain of diplococci, because the division of many individual members of the chain may be going on at the same time. In young cultures the micrococci are uniform in size; but as they grow older a marked difference appears, some of the individuals being twice the normal diameter and more. This streptococcus is nonmotile. On cultivation in gelatin a very thin line appears along the needle track, which is seen to be made up of a row of minute round colonies, whitish in color, rarely reaching the size of a pin's head. There is no growth on

the surface of the gelatin, and no liquefaction or color production. In gelatin plates the colonies also appear as minute whitish globular points, flat and translucent upon the surface. On the surface of agar the growth takes place along the needle track as minute rounded colonies, showing a marked tendency to remain separate. The characteristics upon blood serum are the same as upon agar; on potato there is generally no visible growth; in bouillon there is apparent a very fine cloudiness, which later settles to the bottom of the tube. It coagulates milk, and is said occasionally to produce gas in sugar media and to turn litmus red. It grows best at the temperature of the body, and with a fair degree of rapidity. It does not produce spores, does not liquefy gelatin, and produces no pigment. It stains with any of the anilin colors and by Gram's method. Inoculated into the ear of a rabbit, it produces a localized erysipelatous process; but usually subcutaneous injections in rabbits and guinea pigs are without result.

It must be remembered that one of two things must be true: either there are many kinds of streptococci which our present means of study do not enable us to differentiate, or this streptococcus takes on many variations of virulence under the influence of varying surroundings.

Varieties of Streptococci.—It may be stated that formerly the Streptococcus pyogenes and the Streptococcus erysipelatis were regarded as two distinct species, and various points of difference between them were given. Further study, and especially the results obtained by modifying the virulence, have shown that these distinctions cannot be maintained, and now nearly all authorities are agreed that the two organisms are one and the same, erysipelas being produced when the Streptococcus pyogenes of a certain standard of virulence gains entrance to the lymphatics of the skin. Petruschky in 1896 showed conclusively that a streptococcus cultivated from pus may cause erysipelas in the human subject.

There is occasionally found, in the study of surgical lesions, a bacterium that produces a striking greenish-blue fluorescence in the nutrient media on which it grows. This is the Bacillus pyocyaneus which is of interest not because it produces any pathological changes, but by reason of the studies that have been made upon the pigment which it produces, and its apparently augmenting effect when inoculated at the same time with certain other micro-organisms. It is one of a number, and the characteristics of the group are best studied in the large textbooks.

The Micrococcus tetragenus is also an organism which rarely occurs in surgical lesions, characterized especially by the fact that it divides in two planes at right angles to one another, so that it is frequently found in the tissues after inoculation in groups of four, sometimes surrounded by a capsule. The bacilli stain easily with all the ordinary stains, as well as by Gram's method. This micrococcus is about 1 μ in diameter. It grows readily in gelatin plates, as round, yellowish-white colonies, which appear granular or slightly nodulated under a low power. The surface colonies show the yellowish-white color more markedly. The needle culture in nutrient gelatin gives a fairly thick whitish line along the track of the needle, with a round, thick, yellowish-white disk on the surface. The organism grows abundantly on the surface of agar and of potato, in a moist layer of a yellowish-white color. It grows rapidly at the temperature of the room, does not produce spores, and does not liquefy gelatin. It is especially pathogenic to

white mice, a subcutaneous injection producing a general septicemia, the organisms being found in large numbers in the blood and tissues, especially the spleen. This micrococcus is supposed to be active in the production of the suppurative part of the destructive process in tuberculosis of the lung.

The Bacillus coli communis is found in many inflammatory and suppurative conditions in connection with the alimentary tract; it is found also in other parts of the body, in inflammation of the urinary passages, cystitis, etc. It is a bacillus from 2 to 3 μ long and about 0.5 μ broad, with rounded ends. It is actively motile, and grows in gelatin plates as small brownish-white colonies, not liquefying the gelatin. In nutrient gelatin the growth is well marked along the needle track, as a whitish line, spreading out upon the surface of the gelatin, not much elevated from the surface of the media; on agar it grows distinctly out from the needle track, as a whitish-brown layer, moist, dirty in appearance; the same appearances characterize the growth on blood serum; on potato, in forty-eight hours, there is a distinctly brown pellicle with a dull surface.

The growth clouds bouillon, produces gas in glucose media, turns litmus media red, and has a marked indol reaction in peptone solutions. It grows rapidly (best at the temperature of the body), does not produce spores, does not liquefy gelatin, produces gas, and stains with any of the anilin colors, but not by Gram's method. Intravenous injection of small amounts in guinea pigs will produce death, but much larger amounts are required to produce the same results in rabbits or guinea pigs after intra-abdominal injection.

Muir and Ritchie give the following table of differences between the Bacillus typhosus and the Bacillus coli communis:

B. Typhosus	B. Coli Communis
Flagella more numerous, longer and more wavy.	Flagella fewer and shorter.
In artificial media the growth is generally slow and not vigorous.	Growth faster and more vigorous.
Growth on fresh acid potatoes a nearly transparent film.	Growth on potatoes a brown pellicle.
Very slight acid production in ordinary media, followed sometimes by the production of alkali.	Well-marked acid production.
Fermentation of lactose very slight, if any.	Fermentation pronounced.
Milk not coagulated.	Milk coagulated.
In gelatin "shake" cultures no gas formation.	Abundant gas formation. Rounded colonies.
No production of indol in ordinary bouillon.	Well-marked indol production. In some varieties none (Klein).
Widal's reaction. Bacilli become clumped together and motionless in the serum of a typhoid patient. (A similar reaction is given by the blood serum of an animal immunized against the typhoid bacillus.)	Bacilli remain actively motile.

Of the bacteria already mentioned, the staphylococci are most commonly found in localized abscesses or pustules, carbuncles, boils, in acute suppurative periostitis, in ulcerative endocarditis, and in certain pyemic conditions. The streptococci are usually found in spreading inflammations with or without suppuration, in diffuse phlegmonous and erysipelatous conditions, in suppurations in certain membranes, and in joints. The Bacillus coli communis is found in many inflammatory and suppurative conditions in connection with the alimentary tract and elsewhere. The Micrococcus tetragenus is found especially in suppurations in the region of the mouth or neck, as well as in various lesions of the respiratory tract. The Bacillus pyocyaneus is rarely found alone in pus.

The Gonococcus is a constant accompaniment of that specific form of suppuration known as gonorrhea. Its special characteristic is that it is a micrococcus occurring most commonly in pairs, with the adjacent edges flattened or even slightly concave. Another of its marked characteristics is that it most commonly occurs in the leucocytes, which is different from what is the case in ordinary suppuration. It stains easily and well with any of the ordinary dyes, but does not stain by Gram's method. (See also Gonorrhea.)

Neisser's stain gives very beautiful results. Cover-glasses in warm concentrated alcoholic eosin, two to three minutes. Transfer directly, after soaking off excess with filter paper, to concentrated alcoholic methylene blue for one half to three quarters of a minute. Wash in water, dry, and mount. (These times of staining have been found to be better than those originally given.)

The cultivation of the gonococcus is difficult. It does not grow upon the ordinary media. The best are solidified blood serum and Wertheim's medium, consisting of one part of fluid serum and two parts of agar at a temperature of 40° C., which is then allowed to solidify by cooling. Growth occurs best at the temperature of the body, and does not go on below 25° C. The cultures are to be obtained by passing a small quantity of pus over the surface of one of the selected media, and then placing it in an incubator. The colonies make their appearance at the end of twenty-four hours as small translucent bodies, irregularly rounded, and reach their maximum size on the fourth or fifth day. The later cultures grow more luxuriantly than do the earlier ones, but the transference to fresh media must be made every two or three days.

Diplococcus pneumoniæ (Fränkel's pneumococcus; Microbe of *Sputum septicemia; Micrococcus Pasteuri; Diplococcus lanceolatus*).—Under these headings may be placed a description of the diplococcus that, while not usually producing primary surgical results, may often occur associated with the pyogenic cocci. It is of grave importance in medicine. It occurs not infrequently in the saliva of healthy persons, with great abundance in the expectoration of certain forms of pneumonia, and has been studied, associated with the septic cocci.

The best method of securing a pure culture is that of subcutaneous inoculation of material containing it in rabbits or guinea pigs; in which case the animals will die in from twenty-four to forty-eight hours, and the blood and tissues will be found to be filled with this micro-organism. It is an oval coccus, occurring usually in pairs, and may be surrounded by a capsule. The colonies are not apparent upon ordinary gelatin plates or in gelatin tubes, for the reason that the bacterium does not grow below 22° C., so that cultures are best seen after develop-

ment upon agar at the temperature of the blood. In this case the colonies appear as minute, almost transparent drops, looking almost like small drops of water. They grow best upon blood serum, as an almost transparent line along the needle track, with isolated colonies at the edges, later becoming more or less confluent. The colonies on agar plates are almost invisible, but may be seen by means of a low-power lens, and appear to have a compact, finely granulated center, with almost translucent edges. There is a slight cloudiness produced in bouillon, which later settles to the bottom of the test-tube. There is no visible growth upon potato. It is very difficult to keep the cultures alive, and to do so they must be renewed every three or four days, and even then are fairly certain to die out in the course of two or three months. It is impossible to retain the virulence of the micro-organism under cultivation. This must be done by the passage through animals. Its growth is slow except at the temperature of the body. It does not produce spores, does not liquefy gelatin, does not produce gas, is facultatively anaërobic, stains with the ordinary dyes and by Gram's method, and produces septicemia upon subcutaneous inoculation.

Malignant Edema.—This disease occurs in human beings as a spreading inflammatory edema, accompanied by emphysema, and later followed by gangrene of the skin and adjacent parts. The disease is produced by the bacillus of malignant edema, first described by Pasteur as the "vibrion septique." Like the bacillus of tetanus, this bacillus is present not uncommonly in garden soil, manure, and various putrefying fluids. It is rather a large bacillus, occurring in rods from 3 to 10 μ long, not infrequently growing out into long filaments, but on solid media generally occurring as short rods with somewhat rounded ends. It is motile, with flagella placed on the sides. It forms spores, which are present usually at about the center of the rod. As this bacillus develops only under anaërobic conditions, it may be differentiated by this fact alone from the anthrax bacillus, which it somewhat resembles under the microscope.

In gelatin plates, under anaërobic conditions, the colonies appear as small whitish points, which under a low power show radiating appearances soon masked by a zone of liquefaction. In deep tubes of glucose-gelatin the growth appears as a whitish line, giving off minute short processes, never reaching within an inch of the top of the medium, with the occurrence of liquefaction and the settling of the colonies to the bottom. In deep tubes of glucose-agar at a temperature of 37° C. the growth is very rapid, as a broad white line along the line of puncture, with lateral projections here and there, and a very profuse production of gas. The cultures have a peculiar heavy odor that is quite characteristic. The growth is rapid; it produces spores that are well seen within forty-eight hours at 37° C.; it produces gas, liquefies gelatin, and stains easily with any of the anilin colors, but not by Gram's method; upon subcutaneous inoculation in any susceptible animal it produces the characteristic symptoms of widespread edema, gas production, and gangrene.

For purposes of diagnosis, the microscope is not particularly useful, for, microscopically, the bacillus, unless in the stage of spore production, does not possess characteristics sufficient to identify it. Cultures may be made in glucose-gelatin as roll-cultures, and kept under anaërobic conditions. If the bacilli contain spores, the fluid can be kept at a temperature of 80° C. for ten minutes, and then a deep glucose-agar tube should be inoculated and kept at the temperature of the body.

An inoculation experiment with the suspected material may also be tried in guinea pigs.

Bacillus aërogenes capsulatus[1] (see page 95).

METHODS OF OBTAINING AND CARING FOR PATHOLOGICAL MATERIAL

In surgical work it is customary and necessary to leave the actual identification of the bacteria found in exudates and organs to the pathologist, and for the technic of such procedures the reader is referred to works on surgical bacteriology. A few remarks on the precautions to be adopted by the surgeon in collecting and transferring materials to the pathologist may not be amiss. The materials should be transferred without loss of time. Nothing should be brought in contact with the bacteria which may destroy them, such as antiseptics, nor should they be exposed to extremes of heat or cold. Contamination with extraneous bacteria must be avoided. Fluids may be caught in sterile test-tubes and plugged with sterile cotton or they may be aspirated into a pipette and the ends of the pipette sealed in a flame or plugged with cotton.

Inoculation of Culture-tubes.— A convenient method, and the one ordinarily pursued, is as follows: Two test-tubes are used: one contains a sufficient quantity of sterile nutrient bouillon; the other contains a metal rod tipped with a sterile cotton swab; both are, of course, plugged with sterile cotton. When a specimen is to be taken the metal rod is removed, plunged into the exudate until the cotton swab upon its end is thoroughly smeared with the material to be examined; the cotton plug is then removed from the tube containing the nutrient bouillon; the rod is then introduced into this tube, and the infected cotton swab is agitated for an instant in the bouillon. The rod is then replaced in its tube and the cotton plug along with it; the tube containing the bouillon is again plugged with cotton. The cotton is ignited for an instant in a flame and then blown out, and both tubes are then sent to the pathological department for microscopic examination, cultivation of the bacteria contained in the bouillon, and inoculation experiments, if such prove necessary. The character of the nutrient medium may be varied to suit special conditions.

Organs for Bacteriological Examination.—Organs for bacteriological examination are sent without delay. In order to examine the interior of an organ bacteriologically, the surface may be seared with a cautery iron and a cut made through the seared surface with a sterile knife; cultures and microscopic examinations may then be made from the cut surface.

VARYING SEVERITY OF PYOGENIC INFECTIONS

While, as has been stated, the activities of the several varieties of pus-producing germs are more or less similar, yet, from a practical point of view,

[1] The above details in regard to pyogenic bacteria are largely quoted from H. C. Ernst, "International Text-Book of Surgery." Warren Gould.

it is by no means a matter of indifference whether a given inflammation has been caused by one or the other of several germs. For example, a purulent peritonitis caused by Streptococcus pyogenes is apt to be much more serious than one in which the colon bacillus alone is active. Again, we know that Staphylococcus albus is a germ producing less virulent forms of suppuration than Staphylococcus aureus. There seems also to be more risk of contaminating other patients from streptococcus infections—witness the unusually contagious quality of erysipelas and, in general, a necessity for more vigorous local and general measures in the treatment of these cases.

PATHOLOGICAL CHARACTER OF PYOGENIC BACTERIA

The different forms of pyogenic bacteria possess fairly definite pathological characters, to be now briefly considered: **Staphylococcus pyogenes aureus** is most commonly concerned in the production of boils, carbuncles, circumscribed abscesses, acute suppurative periostitis and osteomyelitis, ulcerative endocarditis, in some cases of purulent peritonitis, and, at present, many observers believe that pyemic infections are more commonly caused by this germ than any other. The **Streptococcus** is especially concerned in the production of spreading local inflammations, often with the production of necrosis of tissue, with or without pus, in phlegmonous processes generally, in erysipelas, and in suppurating joints, in bad forms of puerperal infection, and in the worst forms of purulent peritonitis and peritoneal sepsis. The streptococcus seems to vary greatly in virulence, and the source of the streptococcus producing an infection has a marked bearing on the result. For example, streptococci are found commonly enough on the healthy mucous membrane of the mouth and throat, and in this situation may possess very slight degrees of virulence. When taken from a case of phlegmonous erysipelas or puerperal septicemia the virulence of this germ is, on the other hand, oftentimes of fearful potency.

The **Staphylococci**, other than Staphylococcus pyogenes aureus, appear to have similar pathological characters to Staphylococcus aureus, but they are generally notably less virulent. The white staphylococcus, as was pointed out by Welch, is a regular inhabitant of the human skin—notably of the hair follicles and sweat glands—so that it cannot be destroyed by ordinary means, and may give rise to stitch abscesses after operation and to suppurative processes in wounds, usually of only moderate severity.

The **Bacillus pyocyaneus** is the cause of blue and green pus. It is rarely found alone in infected wounds, and rarely has a special pathological significance. I have commonly seen it as a secondary invader of chronically suppurating wounds. It imparts to the dressings a peculiar greenish color and a musty odor. It is often found associated with Bacillus tuberculosis in open tuberculous lesions.

The **Bacillus coli communis** is found in abscesses and other inflammatory processes in the neighborhood of or originating in the alimentary canal—nota-

bly in ischiorectal abscess and in some forms of appendicitis and peritonitis. It may, however, occur in abscesses in other situations.

The **Micrococcus tetragenus** is often present in the suppurative portion of the lesion of tuberculosis of the lungs, and may be found also in abscesses connected with the mouth and throat.

The **Gonococcus.**—In addition to the ordinary lesions of acute gonorrhea the gonococcus is the cause of a great variety of inflammatory lesions, acute, subacute, and chronic in character, not only in the genito-urinary tract and other mucous membranes, but also in many other situations. In many of these the gonococcus may be found alone, in others associated with other organisms—notably the colon bacillus and the pyogenic cocci. Among the former group may be mentioned peritonitis, gonorrheal synovitis, teno-synovitis, and bursitis, endocarditis, pleuritis, meningitis; among the latter some gonorrheal cystites and acute suppurative lesions of the kidney associated with gonorrhea. The gonococcus is, moreover, capable of producing a general septicemia. The character of the inflammatory exudate in gonorrheal infections of mucous membrane is purulent. In serous membranes it may, as is the case with the ordinary pyogenic cocci, cause serous, fibrinous, sero-purulent or purulent exudation. In synovial membranes sero-fibrinous exudates containing a moderate number of white cells are the rule, though purulent exudates may occur. The gonococcus is capable of causing suppuration in connective tissues, muscles, etc., in the same sense as the pyogenic cocci in rare cases. I know of a case, a young man on the house staff of one of the hospitals of this city, who developed a tedious paronychia on two fingers successively. The gonococcus was identified in the purulent discharge from each. Powers described a case of gonococcus infection of the entire upper extremity.

OCCURRENCE OF PYOGENIC GERMS IN VARIOUS TISSUES

Occurrence of Pyogenic Germs upon the Skin.—The pyogenic bacteria may occur in the human body in various situations without necessarily giving rise to pathological changes. While the general surface of the integument does not afford a favorable soil for the growth of bacteria under normal conditions, yet a great variety of such organisms have been demonstrated upon the skin of healthy individuals as casual inhabitants. The Staphylococcus epidermidis albus of Welch appears, as already stated, to exist normally in the hair follicles and sweat and sebaceous glands. Certain situations are more favorable for the growth of micro-organisms than others—namely, where the surface is moist and two layers of skin are in contact; the axillæ and groins, the skin between the toes, the scrotum, the vulva, the canal of the external ear, the folds of skin beneath the nails, are very commonly the temporary home, at least, of many kinds of organisms. The fingers of surgeons, nurses, and others who come much into contact with pathological material are quite commonly found to contain pyogenic cocci in large numbers. Indeed, the impossibility of

entirely removing such germs has led to the most important advance in the technic of aseptic surgery in recent years—namely, the regular use, by the entire personnel of surgical operating rooms, of sterilized rubber gloves.

From the general integument the pyogenic cocci can, with the exception of Staphylococcus epidermidis albus, be usually removed by suitable mechanical and antiseptic measures, although where the skin is thick and horny the cocci in the deeper layers of the epidermis are not always dead, as shown by cultures made from deep scrapings from such surfaces, even after prolonged and careful efforts at disinfection. The streptococcus is less often found upon the skin than the different varieties of staphylococci, except in cases of persons with infected wounds or who come into contact with sources of infection. The colon bacillus is often found upon the skin near the anus; and the bacillus of tetanus and of malignant edema may be present upon the skin of the feet of those who walk barefooted upon garden soil or who have holes in their shoes. The significance of the smegma bacillus in relation to errors in the diagnosis of tuberculosis of the genito-urinary tract will be spoken of in another place.

Pyogenic Bacteria on Mucous Membranes.—The *conjunctiva*, although exposed in many ways to the entrance of bacteria from many sources, usually gets rid of bacteria quite rapidly. The lachrymal secretion kills some varieties, but most of them find their way in a surprisingly short time through the lachrymal duct into the nose. Thus, although rarely sterile, cultures from the conjunctival sac in health ordinarily furnish few or no pathogenic forms. The *mouth and throat* are continually exposed to the entrance of bacteria of all sorts. A large part of these are got rid of rapidly, but the mouth is constantly the home of a great variety of forms; some of them pathogenic, some of them not. Among the pathogenic forms quite commonly found in the mouth and throat are, according to Welch, Micrococcus lanceolatus, Streptococcus pyogenes, Staphylococcus aureus and albus, Micrococcus tetragenus, Bacillus pneumoniæ of Friedländer, Bacillus crassus sputigenus of Kreibohm, Bacillus coli communis. Streptococcus pyogenes appears very commonly in the healthy mouth. In conditions of inflammation of the mouth and air passages their number is usually notably increased. They may be of slight or great virulence, and are always a cause of anxiety to the surgeon in operations upon the mouth and air passages, because under such circumstances they may and often do produce local and general infections and pneumonias of a grave type. The Staphylococcus pyogenes aureus appears less commonly in the mouth than does Streptococcus pyogenes.

The *tonsils*, owing to their situation, their peculiar physical conformation, and the character of the tissue composing them, are without doubt a frequent avenue of entrance for many varieties of pathogenic germs into the organism. They are not only the seat of numerous inflammatory processes which occur as more or less localized infections of the tonsils themselves, or include also the neighboring tissues, but inflammations of the tonsils and pharynx are exceedingly common as a part of the symptom-complex of a great variety of infec-

tious diseases—notably, the acute exanthemata. Moreover, it has been observed that attacks of acute articular rheumatism and acute osteomyelitis of the long bones are preceded by a tonsillitis in a considerable proportion of cases. The tubercle bacillus has often been found in crypts of the tonsil. The *nasal mucous membrane* acting, as it does, as a filter for the inspired air, may contain in health many varieties of bacteria. The pyogenic cocci are less commonly present in large numbers than in the mouth. The deeper air passages in health contain comparatively few bacteria, the action of the ciliated epithelium being to force them out, and the filtering action of the upper air passages diminishing greatly the number entering with the inspired air.

The Bacteria of the Stomach and Intestine and Biliary Passages.—Enormous numbers of bacteria are swallowed with the food. Theoretically, many of these are killed in the stomach by the gastric juice; practically, many remain alive. In the small intestine the pyogenic cocci are regularly found as well as many other varieties, including the colon bacillus, in some cases Bacillus aërogenes capsulatus. In the large intestine the variety found is less. The colon bacillus is always present. Many of the varieties requiring air find an unfavorable soil, and a considerable proportion are discharged dead with the feces. Tetanus spores may develop into bacilli in the intestine, and tetanus bacilli as well as the bacilli of malignant edema are often present in the intestines of herbivorous animals (Welch).

The Biliary Passages.—In health the bile may be sterile, or, on the other hand, may contain pyogenic bacteria. In inflammatory conditions of the biliary passages, and always in the presence of biliary calculi, the pyogenic bacteria are found in the gall-bladder in greater or less numbers.

Bacillus typhosus may long remain alive and virulent in the gall-bladder, and consequently in the feces, after convalescence from typhoid fever. For example, there is at present confined by the board of health on one of the islands in the East River a woman, a cook, who has carried typhoid infection into a number of families with whom she has lived during the past three or four years. Her feces have contained virulent typhoid germs during all this period. Under medication and a restricted diet the bacilli diminish in number or disappear. When an ordinary diet is resumed they become abundant. This is not a unique case. It is probable that many individuals remain in this way disease carriers for long periods. It is known to be true in numerous instances of diphtheria.

The Male Urethra.—Normally, the male urethra contains bacteria in its anterior portion in varying numbers. The deeper the portion from which the culture is made, the more likely it is to be sterile. Bacteria probably do not exist in the healthy bladder. The bacteria found in the urethra are the smegma bacillus, the Bacillus coli commune, various saprophytic forms, and several forms of diplococci more or less resembling the gonococcus, the differentiation of which will be spoken of under the diagnosis of gonorrhea. True pyogenic cocci may also be found in the healthy male urethra occasionally.

The Female Urethra.—The pyogenic cocci may be present in the female urethra in healthy individuals. It is probable that in healthy virgins the accidental presence of such germs is less common than in women who have borne children and whose vaginæ are more apt to contain bacteria of various sorts, accompanied often by catarrhal inflammation of the cervical endometrium. The *vagina* contains bacteria in considerable variety in health. Doederlein in 1892 described a group of bacilli which grew upon an acid medium. These organisms were nonpathogenic, and were regarded by him as the normal inhabitants of this canal. As to the frequency of the occurrence of the pus-producing bacteria in the vaginæ of healthy pregnant and nonpregnant women various observers differ, but the probability seems to be that their occurrence is rather exceptional. The acid secretion of the vagina seems to have a powerful destructive action on many forms of pathogenic bacteria, such that they are rather rapidly destroyed after accidental introduction. The *normal cervix and endometrium* are free from bacteria, owing, it is believed, partly to the mechanical obstruction to their entrance and partly to the bactericidal quality of the secretions, which are here alkaline in reaction.

The *milk of the breast* contains normally, according to Welch, only the Staphylococcus epidermidis albus derived from the lacteal ducts near their orifices. Other pyogenic organisms may be present in the ducts, but they are less common.

SOURCES OF BACTERIA IN PYOGENIC INFECTIONS

In pyogenic infections the bacteria may be derived from various sources. We may assume that the healthy internal tissues of the body are free from bacteria, or at least that their occurrence is very rare. The bacteria upon the skin may be sources of infection in accidental wounds and in surgical operations where the skin has been imperfectly cleaned, and bacteria in the hair follicles may, as the result of slight traumatisms, such as continued friction, give rise to local or general infections—notably, in persons who are badly nourished. Such infections occur during convalescence from acute diseases, and notably in persons suffering from diabetes and from chronic nephritis. But in by far the largest proportion of cases such infections are caused by bacteria introduced from without; by infected materials introduced into the wound at the time of the accident or during the imperfectly conducted surgical operation.

Another group of infections occurs without mechanical injury. In these the resistance of the tissues to the pus-producing organisms has been lowered by some antecedent infection or depressing condition. In these cases the secondary pus infection often takes place through the tonsils, mouth, throat, and alimentary canal. Thus following the exanthemata—diphtheria, typhoid fever, and other infectious diseases—septic processes occur as secondary infections from the pyogenic bacteria present in the mucous membranes. The depressed states of vitality induced by the antecedent disease has permitted the

pyogenic cocci present to invade and multiply in the tissues. At the present time surgeons are not inclined to lay much stress upon the danger of wound infection from the air. It is quite true that the air of hospital operating rooms may often be demonstrated to contain pyogenic bacteria in varying number; but it is not generally believed that wound infection from this source is common, or at least that the number of bacteria falling into a wound from the air is ordinarily great enough to cause infection.

TOXIC AND OTHER EFFECTS OF PYOGENIC ORGANISMS

The action of the pus-producing organisms upon the human body is of a somewhat complex character. Certain local changes are produced in the tissues in the area where the bacteria are growing—inflammation, suppuration, necrosis; and certain substances are elaborated, due to chemical changes in the tissue fluids, or produced by the bacteria themselves in any medium which affords them nourishment (toxins). The absorption into the lymph current or circulating blood of these toxic substances produces general disturbances of nutrition as well as effects upon the nervous mechanism of the central nervous system. These disturbances are commonly characterized by an elevation of the body temperature, by prostration, by an increased pulse rate, and other symptoms which will be spoken of later. These local and general disturbances bear no very constant relation one to the other. A considerable local reaction may be present without profound intoxication, and severe and even fatal blood poisoning may occur with but trifling signs of local inflammation. In other cases the two sets of phenomena advance *pari passu*.

As we have already seen, the bacteria may enter an open wound. Such wounds as are contused, or which contain masses of coagulated or fluid blood or portions of tissue strangulated by sutures and by ligatures, and wounds the walls of which are in a state of tension from any cause, are more favorable sites for the successful growth of bacteria than are clean-cut wounds in which these conditions favoring infection are absent. Further, the dose of bacteria and their toxins received has an important bearing upon the severity of the infection. A moderate number of bacteria of a certain degree of virulence may cause no interference with wound healing, whereas a larger number may cause serious disturbance. The resistance of the tissues of the individual also plays an important rôle. A person in robust health may get rid of a number of virulent germs which in an individual debilitated from disease, from anemia, from imperfect blood circulation, or other cause, might lead to serious or fatal infection. It is nevertheless true that there are germs so virulent that a few would be sufficient to infect the strongest individual. Personal idiosyncrasy plays also a not unimportant rôle. There are individuals who appear to be much less susceptible to pyogenic infections than others apparently quite as robust and vigorous, and the susceptibility of the same individual no doubt varies from time to time without apparent cause.

Local.—The local disturbances at the site of an infection with pyogenic microbes are due in part to the activities of the bacteria themselves and in part to the effort on the part of the tissues to destroy them and to limit their sphere of activity. The pyogenic cocci produce proteid substances which destroy the vitality of the tissue cells, causing first death and later, by a peptonizing action, softening of the dead tissue. The presence of this bacterial proteid causes what is known as a chemotactic effect; namely, the white blood cells are attracted in larger numbers to the site of infection, and they soon form a living wall around the infected tissues, tending thus to limit mechanically the spread of the bacteria. The leucocytes, moreover, include within themselves numbers of bacteria, and destroy them apparently by a process of digestion. The white cells, also, are believed to furnish a bactericidal substance known as germicidal proteid. If, however, the process is to end in suppuration, many of the leucocytes fail to leave the seat of inflammation alive, and remain with their contained bacteria as one of the ingredients of pus.

The tissue fluids of the body and the blood serum also exercise an inhibitory and destructive effect upon the bacteria by virtue of a substance known as nuclein. In addition to crowded leucocytes, an exudate of fibrin is thrown out by the blood-vessels around the infected focus, so that in many instances the tissues succeed in limiting the bacterial growth to a circumscribed area. The tissues may be so successful that no portion of tissue undergoes purulent softening, and the bacteria are destroyed partly *in situ*, partly by leucocytes which re-enter the circulation, partly by the tissue cells of distant organs in which the bacteria may be transmitted by the blood or lymph current, and partly, also, it is believed, by the endothelial cells lining the capillary blood-vessels. Living bacteria may also be eliminated through the kidneys, through the mucous membrane of the alimentary canal, through the sweat glands, and through the respiratory tract. The pain, heat, redness, and swelling characteristic of local inflammation subside, and the process ends in resolution, so called.

Such a result is often seen in slightly infected wounds after operation; at the end of two or three days after the operation slight redness of the skin is observed along the skin edges of the wound, a little swelling occurs, and the wound edges are a little tender and a little painful. Such swelling and redness will be noted especially at the points under slight tension from sutures. A few drops of sero-sanguinolent discharge may escape upon removing a suture or one of the folded strands of rubber tissue commonly introduced into the ends of skin incisions for purposes of drainage. But the process will stop at this point, no pus will be formed, the symptoms and signs of inflammation will gradually subside, and more or less complete primary union will be obtained in the wound.

If the grade of infection is more severe, the process will end in suppuration. Suppuration may be localized or diffuse. A localized suppurative area is known as an abscess. Diffuse suppuration is often attended by extensive

necrosis of tissue, and is sometimes spoken of as phlegmonous inflammation. Circumscribed suppuration is most often caused by Staphylococcus pyogenes aureus; diffuse suppuration by Streptococcus pyogenes.

Furuncle.—The diagnosis of abscess, if situated near the surface, is easy; if in an internal organ, it may be extremely difficult. Among the commonest forms of superficial abscess is a boil or furuncle. Furuncle is an acute purulent inflammation of the skin around a hair follicle or cutaneous gland; it is caused most often by Staphylococcus pyogenes aureus. Depressed states of health, diabetes, and convalescence from acute diseases predispose to the occurrence of furuncle. The boils may be solitary, or several may occur in the same region or scattered over various parts of the body (furunculosis). It is probable that infection is often carried by the fingers to other parts, causing new foci of infection. Continued mechanical irritation is often the exciting cause of furuncle, as, for example, horseback riding, rowing, the friction of a collar button upon the back of the neck.

The favorite sites of furuncle are, as suggested, the nates, the back of the neck, the face and back, and sometimes other regions. A furuncle begins as a minute red, tender point surrounding the orifice of a cutaneous gland or hair follicle. The subjective sensation of itching and tenderness are early present. The red area increases in size, and in the course of two or more days may become as large as a silver dime or twenty-five-cent piece. It is elevated above the level of the surrounding skin, conical in shape, bright red in color. It may be quite painful, and is very sensitive on pressure. At the center of the swelling there soon appears a round, white or yellowish spot; a thin pellicle of skin covering this area permits the yellowish color of the underlying pus to shimmer through. If the pellicle is ruptured, the exuding drop of pus dries into a crust.

If the boil is incised at this time, a small cavity from one quarter to one half inch deep will be opened, containing a few drops of pus and a central necrotic mass representing the original focus of infection and surrounded by more or less necrotic tissue. If the furuncle is allowed to rupture, a few drops of pus may be squeezed out, followed by a minute slough—the so-called core of the boil. During the height of the process, and before incision or rupture, moderate fever and leucocytosis may be present. Healing follows by granulation, with gradual subsidence of the inflammation. In enfeebled individuals a boil or congeries of boils may form with the production of a carbuncle.

Carbuncle.—Carbuncle is a suppurative and necrotic inflammation of the skin and subcutaneous tissues. Staphylococcus pyogenes aureus is the organism most frequently concerned in the process. Carbuncle is rare in childhood, and is most frequent after the fortieth year of life. The most common sites are the back of the neck, the back, and the lip. The disease commonly attacks persons not in robust health, those convalescing from acute diseases, diabetics, and chronic alcoholics, but healthy adults may also suffer. In these the constitutional symptoms may be slight, but in the debilitated and diabetic, grave

constitutional depression accompanies the disease, and the prognosis is most serious. The disease may begin as a simple furuncle, or as a number of furuncles in juxtaposition; the process is not limited to the skin, but extends laterally and into the subcutaneous tissues, following the columns of fat which lie between the connective-tissue bundles. In size, carbuncle varies from that of a silver half dollar to that of a dinner plate. It is usually solitary. The inflamed area is deeply red, sometimes purple, elevated above the surrounding skin, and oval or rounded in shape. The swelling is hard, tender, painful, and firmly adherent to the deeper structures. After a few days numerous small openings form upon the surface, and through them a thin pus exudes.

Fig. 14.—Carbuncle of the Back. (New York Hospital.)

If not operated upon, a large carbuncle may take ten days or two weeks to fully develop. Sloughing of the overlying skin finally occurs, sometimes over a large area; the skin becomes riddled with openings like a sieve, and through the openings thus formed sloughing masses of connective tissue and pus are discharged. Necrosis of the infected tissue leads to a soft, boggy condition of the central mass, surrounded by a dense, hard area of infiltration. When carbuncle involves the neck and back, the sloughing usually extends to the fascia covering the muscles, and the extent of the infection of the deeper tissues is often greater than the inflamed area of skin would indicate.

The *constitutional disturbance* attending carbuncle is often severe. In old and feeble persons, and in the diabetic, the constitutional depression is extreme. In ordinary cases there will be moderate fever of a remittent type, and a corresponding rapidity of pulse-rate. Leucocytosis is present, and varies according to the size and severity of the infection. In the aged and diabetic, leucocytosis may be wanting, the polynuclear cells will show a relative increase, fever may be absent, but the pulse will be rapid and feeble and the weakness extreme; anemia is often pronounced. Fatal septicemia, or death in diabetic

coma, are not uncommon. *Carbuncle of the lip* is dangerous, and even fatal in certain cases from purulent phlebitis of the veins communicating with the interior of the skull, resulting in sinus thrombosis and pyemia or in meningitis. Carbuncle of the lip may end in this manner even in young and robust individuals (see Face).

Phlegmonous Inflammation.—By phlegmonous inflammation we understand that form of infection with pyogenic microbes which is attended rather by necrosis and sloughing of the tissues than by the mere production of pus. Purulent softening and suppuration of the living tissues at their junction with the dead parts is a later development of the process in many instances; in others the purulent and necrotic processes advance hand in hand. Clinically we may distinguish two forms of phlegmonous inflammation—the *circumscribed* and the *diffuse* or *spreading phlegmon*. The microbes concerned in the diffuse form are often Streptococcus pyogenes. There may be a formation of gas in the tissues, and putrid decomposition of the sloughs due to the growth of saprophytes.

Circumscribed Phlegmons.—These are caused sometimes by the Staphylococcus pyogenes aureus. The origin of the inflammation is often in a trifling wound or abrasion of the skin, in a needle puncture, a blister, an inflamed bursa, an ulcer of the leg; sometimes in a small abscess, such as abscess of the pulp of the finger; sometimes in severe injuries, such as compound fractures of the extremities and crushing injuries. Sometimes the bacteria are taken up by the lymph vessels, and make a successful lodgment in the communicating lymphatic glands, and produce phlegmonous inflammation in their vicinity (see Lymphangitis). The tissues involved in phlegmonous inflammations are the skin, the subcutaneous tissues, the tendon sheaths, the fascia and the fascial and loose connective tissues of the intermuscular planes, rarely the muscles and periosteum; sometimes joints are invaded. In not a few instances of the severer forms of this type of infection septicemia and pyemia are fatal complications. The signs and symptoms of phlegmonous inflammations will vary according to the process and the severity of the infection.

Constitutional Symptoms.—The constitutional symptoms are ordinarily marked, and consist often, at the beginning, of chilly sensations or a distinct chill, accompanied by a rise of temperature which will vary according to the activity and extent of the process. The temperature may rise suddenly to 102° or 104°, or in severe cases to 106° F. The pulse will increase in rapidity to an extent commensurate with the temperature, or in the most rapidly fatal cases there will be little or no rise of temperature, but a rapid, compressible pulse almost from the first. At first the pulse will be full and bounding; later, if the case goes badly, more and more rapid and feeble. There will be the ordinary symptoms of septic intoxication: headache, loss of appetite, a coated tongue, and prostration. The *pain* will depend to some extent upon the swelling and tension, and upon the nerve supply of the part. For example, a phlegmonous process confined beneath the dense fascia of the palm is far more

painful than a similar process of the upper arm or thigh. The local signs also will vary to some extent, depending upon whether the skin is early involved or not.

A Typical Phlegmon of the Palm.—A typical phlegmon of the palm may be described as follows: After a slight infected wound or abrasion of a finger or a blister upon the palm of the hand, the patient suddenly begins to feel ill; he has chilly feelings or a chill, and a rise of temperature to 102° or 103° F.; a throbbing pain is felt in the hand, which is severe enough to prevent sleep. The hand becomes swollen, but redness of the skin is absent or slight. The palm becomes very tender in the neighborhood of the original focus of infection; as the days go by, the whole hand becomes swollen and edematous, and the swelling extends to the forearm. The skin is often but little reddened; the throbbing pain increases in severity, and the patient feels seriously ill. The fever is of the remittent type, and is usually higher in the evening. There is complete anorexia, much prostration, and sleeplessness. Leucocytosis will always be found, of moderate or considerable degree. The large polynuclear forms will be relatively increased seventy to ninety-five per cent. The original focus discharges a little pus on pressure, and the whole palm becomes exceedingly painful and tender.

If no incisions are made the swelling extends upward to the elbow, the whole hand becomes greatly swollen and edematous, suggesting the bloated appearance of the abdomen of a frog (Frog Felon). If at the end of a week or ten days incisions are made into such a hand, pus will be found confined beneath the palmar fascia, usually in large quantity, and the connective tissue of the palm and the tendon sheaths of the flexor tendons will be found necrotic and infiltrated with pus. If the forearm is squeezed, pus will be seen coming down into the palm from beneath the annular ligament of the wrist, and an appropriate incision will reveal a more or less extensive necrotic and purulent infiltration of the deeper connective tissues of the forearm, of the intermuscular planes, and of the tendon sheaths of the flexor muscles.

If incision is still longer delayed, the skin will be perforated here and there in the hand and in the forearm, and from the openings pus and necrotic masses of connective tissue and tendon sheaths, and later tendons, will be extruded. *If incisions of proper character are made early, the function of most or all of the tendons of the hand will be preserved*; if not, the tendon sheaths will be successively and insidiously invaded until the whole hand and the palmar aspect of the forearm become riddled with purulent and necrotic tracts, and the end result will be sometimes septicemia and death, sometimes a crippled hand, and sometimes merely a contracted and useless claw upon which the subsequent measures of massage, passive motion, and the like will be of small benefit.

Diffuse or Spreading Septic Phlegmon (Septic Cellulitis).—A more severe type of the disease—a spreading septic phlegmon—may be illustrated by a case which came under my observation:

A large, vigorous laboring man entered the hospital with the following history: He had enjoyed good health until five days before admission. For several years he had a small bursa over the olecranon process of his right ulna: five days before he had scratched or abraded the skin over this bursa; the same night he had a chill followed by fever and sweating and his elbow had become painful and a little swollen. His general condition had continued to grow worse; the swelling of his elbow had extended up and down his arm; and on the fifth day he was brought to the hospital in the ambulance very ill indeed. Upon admission his temperature was 105° F.; pulse 120; his face was flushed; his tongue dry and coated; he complained of feeling much prostrated and had a great deal of pain in his right arm. Upon examining his arm it was noted that the limb was swollen from the wrist to the shoulder to nearly twice its normal size. The skin of the arm and forearm was bright red in color and edematous (cellulitis); the redness extended from the wrist to the shoulder-joint. Over the point of the elbow was a small perforation in the skin from which thin pus exuded on pressure. Cultures from this pus gave a pure culture of Streptococcus pyogenes—leucocyte count 35,000, eighty-five per cent polynuclears.

Under ether, an incision was made along the dorsum of the limb from the shoulder to the wrist. The subcutaneous tissues of the dorsum of the limb were found everywhere necrotic and infiltrated with a thin purulent fluid, and were dissected up a considerable distance on either side of the incision. The limb was dressed in a suitable manner and suspended vertically by a splint and pulley. After forty-eight hours his fever, which had remained high, began to subside. The leucocytosis, which had been 35,000 on admission, fell to 12,000. The relative percentage of large polynuclears underwent a marked diminution. At no time did cultures from the blood give positive evidence of live bacteria in the circulation. After a long convalescence he recovered with a useful limb.

Mixed Infection, with Streptococci and Saprophytic Bacteria (Proteus).—The most severe type of phlegmonous inflammation combined with infection with saprophytic bacteria is well illustrated by the following case:

A young man was accidentally shot in the forearm by the discharge of a shotgun; the charge produced a ragged hole in the limb just below the elbow, tearing the skin, muscles, and bones in a destructive manner. He was brought to the hospital three days later. Upon admission he was delirious; his pulse was 140; his temperature 103.6° F.; his face was pale and his body was bathed in a clammy sweat. Upon examining his arm the wound was found to be a ragged hole through the limb about two inches in diameter; the surface of the wound was necrotic and gave out a putrid odor. The entire limb as far as the clavicle was greatly swollen and of brawny hardness. The surface of the upper arm was of a deep, dark-red color and covered with blebs containing a blood-stained serum; upon palpation the subcutaneous tissues crepitated, showing the presence of gas beneath the skin.

Incision into the limb showed a necrotic condition of the subcutaneous tissues, which resembled bacon in appearance. Amputation was done at the highest possible point at once, but the young man never regained consciousness and died a few hours later. Cultures showed the presence of Streptococcus pyogenes and of sapro-

phytic bacteria. No leucocyte count was made. Death was due to sudden and profound septicemia and sapremia. (See Diagnosis of those diseases.)

THE DIAGNOSIS OF LOCALIZED FOCI OF SUPPURATION (ABSCESS)

Circumscribed purulent foci or abscesses may occur as the result of a great variety of conditions, traumatic or other, complicated by infection with pyogenic organisms. They may occur in the most varied regions of the body, and the diagnosis of many varieties will be spoken of under the head of Regional Surgery. Favorite sites for abscess are the skin and subcutaneous tissues, the lymphatic glands, the loose connective tissue of the neck, of the ischiorectal fossa, the periosteum, the kidney and perirenal tissues, the liver, and the pelvic viscera of the female. Circumscribed purulent collections also occur in many other situations—in the bones, the joints, the pleural cavity, the peritoneum, and elsewhere—but these purulent accumulations generally receive special names, as, for example, circumscribed osteomyelitis, purulent arthritis, empyema, localized purulent peritonitis, etc.

PHYSICAL SIGNS AND SYMPTOMS OF ACUTE ABSCESS

The signs and symptoms of acute abscess, wherever situated, are partly due to the abscess itself and partly due to its proximity to other organs. The signs and symptoms of acute purulent inflammation are usually present—namely, pain, heat, redness, and swelling, and, after purulent softening has taken place, fluctuation, if the abscess be so situated as to enable this sign to be appreciated. Constitutional disturbance is also present, and is discussed at length under the head of Septic Intoxication.

Pain.—As already noted, the pain of abscess varies greatly with the situation. When situated in loose connective tissues pain may be slight, even though the abscess be extensive—for example, in the subcutaneous connective tissue of the thigh or arm. On the other hand, the pain due to the tension of the inflammatory exudate, when situated in unyielding tissues or in the neighborhood of sensitive nerve trunks, may be excruciating, even though the focus is small—for example, purulent collections in the medulla of the bones, in the wall of the canal of the external ear, beneath the dense connective tissue of the pulp of a finger or toe, or in the tongue, are usually exceedingly painful.

The pain of abscess goes on increasing until the tension of the pus is relieved by incision, or by necrosis and perforation of the surrounding tissues and the escape of the pus. Such perforation may take place through the skin or mucous membrane, through the bone beneath the periosteum, into a joint, into the interior of the skull, into the peritoneal cavity, etc., or simply into an area where the connective tissue is less dense. The mere diminution of pain, then, does not necessarily mean a betterment of the condition; it may be an indication that the pus has invaded new and perhaps far more important structures, and

that locally the tension is thus relieved. When poultices were commonly used in the early stage of the abscess, the heat and moisture often broke down nature's limiting barriers, permitted the pus to burrow into the surrounding structures, and thus caused temporary diminution of pain.

The pain of abscess is usually of a throbbing, boring character, and is commonly, though not always, felt at the site of the inflammatory focus. It is often worse at night, and is generally somewhat relieved by the maintenance of a posture diminishing the arterial blood-pressure and favoring venous return by gravity—for example, by vertical suspension of a hand and arm, the seat of abscess. There are, however, many exceptions to this rule; where abscess presses upon the nerves, the pain may be felt over the whole or a part of the distribution of the nerve, and thus be felt in situations far removed from the focus of inflammation. Thus, pain of an abscess at the root of a tooth is not infrequently felt over the entire distribution of the fifth nerve of that side. The pain of abscess in or near the hip-joint is often felt in the knee. The pain of abscess of the prostate is often most severe in the glans penis and in the rectum, and the pain of abscess of the kidney is frequently severe in the urinary bladder. The individual instances of the type of referred pain will be discussed under Regional Surgery. The pain of abscess appears to be almost entirely due to pressure upon the nerves of the inflamed part, especially to the infiltration and pressure of the inflammatory exudate upon the smaller nerves. If this tension is relieved by incision or rupture of the abscess, the pain diminishes rapidly, and often entirely disappears at once or in a few hours.

Heat.—In addition to the general rise of body temperature, a part of the seat of abscess is supplied with an increased amount of blood, and is warmer to the touch than the surrounding tissues. When an abscess is superficial, this increase of temperature is readily appreciated by the hand laid upon the part, or if less marked one hand may be laid upon the corresponding part of the body of the healthy side, and thus the difference in temperature may be appreciated. A surface thermometer may even be used for the same purpose. The increased local heat can only be appreciated in case the abscess is near the surface; in cases of abscess of deep-seated tissues and organs it will not be present.

Redness.—Redness of the skin is present in superficial abscesses. If the abscess is immediately beneath the skin, the color will be of a bright and vivid red, often sharply circumscribed from the surrounding skin and unmistakable. If the abscess is more deeply seated, the redness will be more diffuse, less vivid, and often so slight as scarcely to be noticeable. If the abscess has nearly perforated the skin, the redness may be of a dark or purple hue, and if perforation is about to occur, the skin will be white, yellow, or blue over the necrotic area. If the abscess be very deeply seated, no change at all in the color of the skin may be noted, and in some of the most violent suppurative and necrotic lesions of the subcutaneous tissues the skin may be quite white or normal in appearance.

The heat and redness of acute inflammation and abscess are an expression of the reaction of the tissues to the noxious influences of the bacteria; hence, as might be expected, when this reaction does not occur, or is but slightly marked, these signs will be absent or less prominent. This is well illustrated in some of the secondary abscesses occurring in the subcutaneous tissues, in some cases of pyemia, in many cases of diabetes; and, indeed, under all conditions, when the resistance to the spread of the pyogenic process is very feeble, one notices this absence of reaction on the part of the tissues, notably in the secondary pus infections following acute diseases, typhoid fever, and in some of the pyogenic infections occurring in locomotor ataxia, and sometimes in the secondary abscesses complicating erysipelas. Such purulent collections may only be discovered by accident, a very little tenderness and a boggy or fluctuating swelling being the sole indications of the presence of pus. Upon incising such abscesses, the pus will be found existing under very little tension, the walls of the abscess will be necrotic, and little or no evidence of an effort to limit the spread of the inflammation on the part of the tissues will be observed. Such a want of reaction is, in general, indicative of feeble vitality, and is of rather unfavorable prognostic significance.

Swelling.—The swelling produced by abscess will vary according to the size and situation of the purulent focus, according to the severity of the infection and the reaction of the tissues, as well as with the character of the tissues surrounding the accumulation. Sharply localized processes, such as furuncle and carbuncle, produce under ordinary conditions sharply defined, prominent swellings. Abscesses within dense, unyielding structures may produce no localized swelling at all, or only a swelling indicating a general interference with the circulation of a limb. Thus, a long bone—the seat of acute purulent osteomyelitis—may not be increased in size, but often the whole limb will be swollen and the superficial veins dilated owing to the general interference with the venous circulation. Wherever the tissues are lax—as, for example, the prepuce, the scrotum, the eyelids, and in certain other regions—the swelling will be great—out of all proportion to the size of the purulent collection.

Abscesses in the large cavities of the body may produce no visible nor palpable swelling at all, or the swelling of the overlying soft parts may give some sign of the trouble within. An abscess within a bone or bony cavity, if it has existed for some time, may produce absorption of bone with irritation of the overlying periosteum and the production of new bone, and the bone may thus be actually increased in size, and give rise to a palpable and visible enlargement. In purulent collections in the mastoid process of the temporal bone we often see inflammatory swelling and edema of the overlying soft parts. In purulent inflammations of the frontal sinus and of the antrum of Highmore, actual dilatation of the walls of these cavities may take place with corresponding swellings of the surface. In the long bones, when purulent collections exist for some time without perforating the cortical layer, similar en-

largements are sometimes observed. This is more often the case in tubercular and fibrinous inflammations of these bones. (See Spina Ventosa.)

When a purulent focus exists in one of the abdominal organs, swelling may sometimes be appreciated by careful palpation. It will not usually be possible under such circumstances to do more than make out an enlargement of the organ in question, and from concomitant symptoms, such as tenderness, rise of temperature, leucocytosis, septic symptoms, etc., to pronounce the probable presence of pus. It sometimes happens even here that the signs are sufficiently marked to render a certain diagnosis possible, notably in diseases of the uterine adnexa, the kidney, the vermiform appendix, etc. (See the Diagnosis of Diseases of the Abdomen.)

Fluctuation.—Fluctuation is the sensation transmitted to the fingers when pressure is made over a cavity containing fluid under tension. By the pressure of the fingers on one portion of such a cavity the tension of the fluid is increased, and this increase of tension is appreciated by the finger or fingers of the other hand placed upon some other portion of the wall of the cavity. The fluid being incompressible, the fingers are raised or lifted on the one side when the wall of the cavity is depressed on the other. While the sensation of the fluctuation is a valuable diagnostic sign in cases of abscess, it must be remembered that fluids other than pus give the same sign, and that in case the amount of pus is small and deeply seated, fluctuation may be entirely absent. It would be a grave error to suppose that every reddened and inflamed area in which the sign of fluctuation can be detected is necessarily an abscess, or, on the other hand, that the absence of this sign indicates that no pus is present or that an incision is uncalled for. In those forms of infection characterized by a rapid spread of the process with progressive necrosis of the tissues, fluctuation may be absent from first to last, and fluctuation may be present where no pus exists and where an incision may lead to disastrous results. It has happened many times that surgeons have incised what appeared to be an inflammatory tumor characterized by all the signs of acute inflammation, only to find that they have opened into an aneurism.

Manifestly, in many regions of the body the sign of fluctuation is obtainable with difficulty, if at all. This is, of course, true of purulent collections inclosed in bony cavities, of abscesses deeply placed beneath dense and unyielding structures, even though these be quite superficial, as, for example, in the palm of the hand and in the submaxillary triangle of the neck; and in many other situations the mere thickness of the tissues intervening between the examining hand and the purulent focus, together with the increased resistance due to inflammatory infiltration, will render the appreciation of the sense of fluctuation difficult, uncertain, and even impossible. If other signs and symptoms indicating the presence of pus are present, it is unwise and irrational under many conditions to wait for this sign. In the examination of inflamed joints for the detection of fluid, the sign of fluctuation is sometimes of great value. It is sometimes possible by making pressure with the fingers over

several portions of the joint at the same time to elicit this sign with certainty. A more detailed description of the method will be given under Regional Surgery and under Diseases of Joints.

Tenderness.—A very valuable sign of the probable presence of pus in an acutely inflamed area is the detection of a fixed point of extreme tenderness. In many situations, when taken together with other signs of purulent infection, such a point of tenderness is of the utmost diagnostic value, not only indicating the probable presence of pus, but also furnishing the surgeon with a reliable guide to the position of his incision. This holds true not only of the more superficial abscesses, but also of those more deeply situated. It points to the place for incision as well in abscesses in the pulp of the finger as in cases of osteomyelitis of the long bones and inflammations of the interior of the abdomen—as, for example, in abscesses in the neighborhood of the vermiform appendix. Of all the signs of the presence of pus, this is perhaps the most valuable. Other local signs of suppuration will be mentioned in their appropriate places.

Special Symptoms of Acute Abscess.—Other special symptoms may be produced by the pressure of inflammatory exudates including abscess—for example, interference with the function of nerve trunks by pressure, causing partial or complete paralysis of the region supplied by the nerve, either sensory or motor; interference with the caliber of hollow viscera, such as the trachea, causing dyspnea, or the intestine, causing complete or partial occlusion of its lumen. The pressure of a purulent collection within the cranium may cause the most varied symptoms due to the inhibition of the function of any portion of the cerebrum or any of the cranial nerves. Under such circumstances it is obvious that a focus, even of small size, may give rise to serious or even fatal symptoms.

Pressure upon blood-vessels—notably veins—may give rise to disturbance of the function of the limb, to great swelling and edema, and dangerous disturbances of nutrition. Abscess in the neighborhood of the urethra and in the prostate may often cause retention of urine. Purulent collections in joints usually cause total or partial loss of function in the joint involved. The distention of the joint causes severe pain, and the individual involuntarily places the joint in such a position as to relieve such tension as far as may be; the muscles of the limb are spasmodically contracted when passive efforts are made to move the joint surfaces one upon the other, and the limb is thus held rigidly fixed. Crowding the surfaces of an inflamed joint together also gives rise to extreme pain.

The Use of the Aspirating Needle.—An ordinary hypodermic syringe, or one of larger size, armed with a hollow needle of variable length, according to the thickness of the tissues to be penetrated, is much used for diagnostic purposes to determine the presence or absence of pus, or the character of a fluid contained in an inflamed area, in a joint, in a tumor, in the pleural cavity, or in certain of the solid organs of the abdomen. The method of its use is simple.

The syringe and needle, properly sterilized—best by boiling—is thrust into the suspected tissues, cavity, tumor, or organ, as the case may be, the surface of the skin having been carefully scrubbed and disinfected beforehand, and the entire procedure being made with the same precautions which would properly accompany a surgical operation. The piston of the syringe is slowly drawn out of the barrel, thus aspirating any fluid thin enough to pass through the needle into the barrel of the syringe, so that its character may be observed and studied.

The method is used to a great extent to determine the character of exudates in the pleural cavity, occasionally the quality of the fluid contained in an

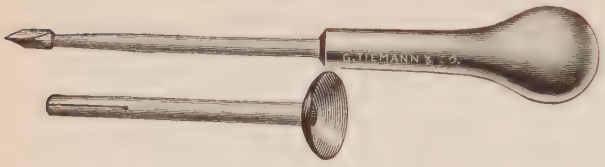


Fig. 15.—Trocar and Cannula.

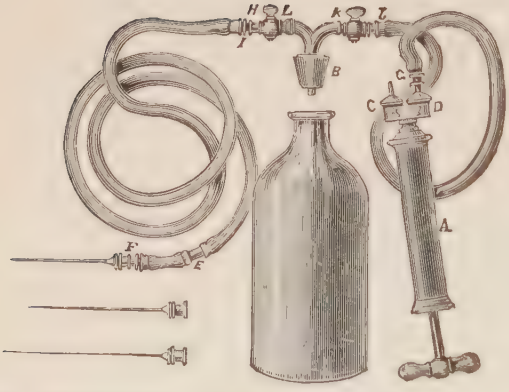


Fig. 16. -Potain's Aspirator. (W. F. Ford & Co.)

Fig. 17.—Dieulafoy's Aspirator. (W. F. Ford & Co.)

inflamed joint, and sometimes in cases of suspected abscess of the liver. It is sometimes used to detect the presence of pus in ordinary superficial abscesses. It may be a valuable guide to the situation of a purulent collection when the amount of swelling or edema is great and the exact situation of the purulent focus is doubtful. In certain deep-seated abscesses of the neck, accompanied by much swelling and brawny edema, the use of the aspirating needle is at times not only justifiable, but desirable. In some of these cases the purulent exudate is small and the inflammatory infiltration is very extensive, and a

single drop of pus aspirated through a needle may afford a valuable indication of the depth and situation of the abscess. The fallacies connected with the use of the aspirating needle are: the purulent focus may be missed entirely; the pus may be too thick to enter the needle; a blood-vessel may be punctured, and blood instead of pus may be obtained, although pus may exist at another level.

The dangers in the use of the aspirating needle are: the infectious material may be carried into new and more dangerous regions; important vessels or nerves may be wounded; if an abscess cavity is entered and the needle withdrawn, leakage of the pus may occur into a large body cavity, sometimes with dangerous or fatal results unless the aspiration is followed at once by incision. Under no circumstances should an aspirating needle be thrust into the peritoneal cavity unless absolute certainty exists that the organ to be explored is adherent to the parietal peritoneum over a considerable area. During operations upon the abdomen, on the other hand, the aspirating needle is of great use under a variety of conditions, which will be spoken of under Regional Surgery. It is also valuable in determining the character of fluid accumulations, other than pus, in many conditions.

DISEASES OF WOUNDS

Aseptic Wound Fever, Sapremia, Septic Intoxication, Septicemia, Pyemia, and their Combinations

This most important group of constitutional disturbances following wounds may be conveniently considered together.

Aseptic Wound Fever.—As its name implies, aseptic wound fever is used to designate certain constitutional disturbances sometimes observed after injuries, whether open wounds or subcutaneous traumatisms, unaccompanied by bacterial infection. Other names which have been given to it are Ferment Fever (von Bergmann), Resorption Fever, After Fever (Billroth). The symptoms are observed most often where a considerable quantity of effused blood exists in the depths of a wound, or where, in the case of a subcutaneous injury, much blood is extravasated into the tissues. It was formerly believed that the symptoms were caused by the absorption of the fibrin ferment formed in the extravasated blood. At present it is believed to be caused by the absorption of nucleins and albumoses, substances occurring in such blood, and identical symptoms have been produced by the introduction of these substances into the circulation of animals. The condition may be almost absent after severe operations, or may follow comparatively trifling operative procedures. Imperfect hemostasis, bruising and strangulating of tissues favor its occurrence.

Symptoms of Aseptic Wound Fever.—The symptoms are as follows: Within twenty-four hours, usually, after the injury or the operation the temperature of the patient rises to 100° or 101° or 102° F., seldom higher. The pulse also becomes correspondingly rapid; the patient's face is often flushed;

there is sometimes slight headache. Usually the subjective symptoms are so slight that the patient feels quite well and comfortable; the temperature usually falls to normal within forty-eight hours, unless some other cause for the continuance of the fever is present or is developed. The signs and symptoms of wound infection are absent. Some slight disturbance of this kind is the rule rather than the exception after surgical operations of any considerable magnitude, and does not give rise to anxiety on the part of the surgeon.

In some cases the symptoms will be more marked. The patient will complain of pain and of a feeling of tension in the wound. An examination of

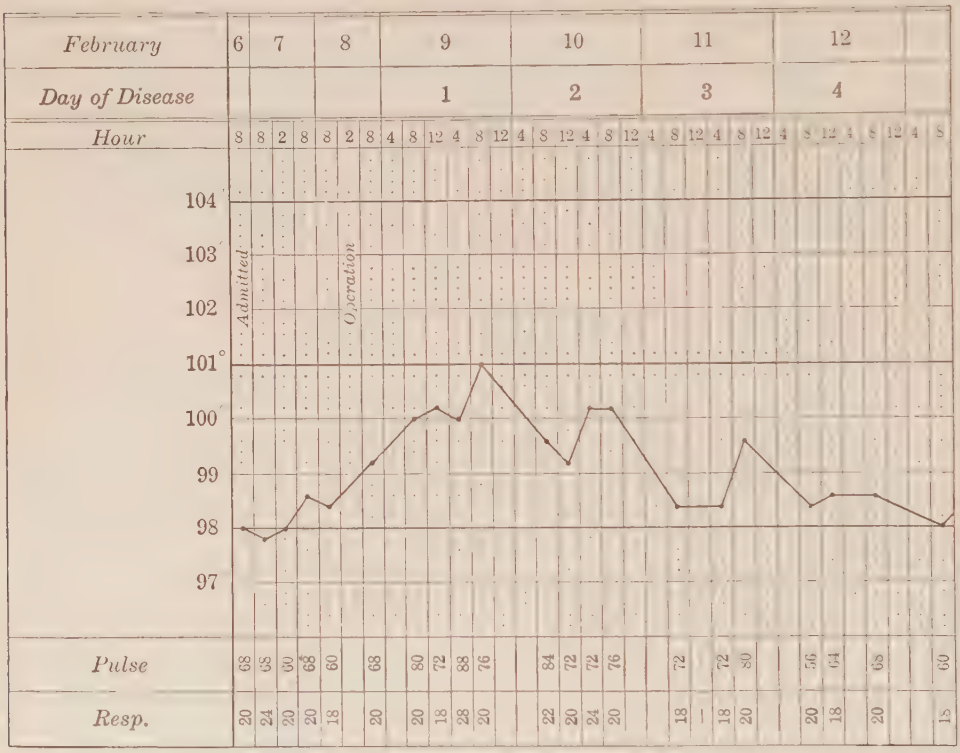


Fig. 18.—Temperature Chart of a Case of Aseptic Wound Fever.

the wound upon the following day will show the suture line not reddened, but the surrounding area may appear unduly prominent, and a sense of fluctuation may be transmitted to the examining fingers. The wound will be found distended with bloody serum, or with fluid blood or partly clotted blood. Evacuation of the foreign material will be followed by a subsidence of the fever, and if the wound remains clean the temperature will not rise again. The recognition of such a state of affairs is highly important, because while operative wounds heal under proper conditions without giving evidences of the presence of bacteria, yet our technic is not so perfect as to exclude all germs from wounds; and while a clean, dry wound in which a few bacteria of suppuration

are present will often heal *per primam*, the presence of a considerable quantity of blood in the wound will greatly favor the multiplication of such bacteria as may be present, and wound infection may follow unless the blood be removed at an early date.

The accompanying temperature chart represents the course of aseptic wound fever as ordinarily observed. The chart is that of a case in which an operation for the radical cure of inguinal hernia was done upon a healthy male adult. Primary union occurred in the wound.

Sapremia—Putrid Intoxication.—Sapremia is the name used to designate the condition produced by the absorption into the system of the excretory products of the saprophytic bacteria—the bacteria whose growth takes place in dead organic matter, the bacteria of putrefaction. It is probable that a pure sapremia—that is to say, a condition of poisoning due to the saprophytes alone without the additional toxemia of one or more of the pus-producing organisms—is a comparatively rare occurrence. The disease is an acute poisoning due to the presence in the body of putrefactive material. Such material may be a putrid blood clot in the depths of a contused wound, a mass of decomposed placenta in the parturient uterus, a gangrenous limb, or a strangulated coil of gut in a hernial sac, or some other mass of dead tissue in which the bacteria of putrefaction are multiplying.

Symptoms of Sapremia.—In most cases the history and local findings are sufficient to point clearly to the source of the poison. The symptoms of the disease are those of a fairly sudden intoxication. In some cases a rapid rise of temperature will be the first symptom. In others the fever will be preceded by loss of appetite, headache, and prostration; the temperature may rise in a few hours to 104° or even 106° F.; the pulse will be accelerated to a corresponding extent. Sometimes the rise of temperature is accompanied by a chill. In the most severe cases, such as may follow putrefactive changes suddenly taking place in a crushed or strangulated extremity, the absorption of the products of putrefaction may be so rapid that death occurs in a day or two. After the initial chill and rise of temperature the entire organism may be overwhelmed by the poison. The patient will become delirious in a few hours; the delirium may pass rapidly into stupor or coma. The circulation will be profoundly affected from the outset; the heart will beat rapidly, and speedily become more and more feeble; the surface of the body will be cold, bathed in a clammy sweat, and pale or cyanotic. The expression of the face will be dull and apathetic.

The onset of the symptoms may be so sudden and severe as to resemble the condition of shock. Death may take place from failure of the heart, sometimes with a very high temperature and sometimes with a temperature which is subnormal. Such a violent course is, however, uncommon. Usually following the chill and fever there will be marked prostration, headache, vomiting, diminution in the excretion of the urine, sometimes diarrhea. The headache will be followed by delirium, restlessness, later by coma, a rapid and failing

pulse, and death. In other cases, if the amount of putrid material be small, the process may be self-limiting. The bacteria may use up the pabulum necessary for their further propagation; the poisons will cease to be manufactured and absorbed, and the individual recover.

Diagnosis of Sapremia.—It is, however, by the results of surgical interference that the diagnosis may be most clearly established and the presence of the pus-producing bacteria as active elements in the condition may be eliminated. If the case be one of pure sapremia, the operative removal of the dead material will usually be followed by an immediate subsidence of all the symptoms. The general condition of the patient rapidly improves; the fever subsides, and does not return. The diagnosis of sapremia is to be made then in the presence of a focus of dead material within the body. The signs of putrefaction—a putrid, foul, or disagreeable odor—will be present if the focus communicates with the exterior of the body. A wound will usually be tender and painful, and will give forth a thin and watery, or blood-stained, evil-smelling discharge. The constitutional symptoms will vary in severity, as described, according to the amount of putrid material, the activity of the bacteria, and the size and character of the absorbing surface. Should the symptoms continue after the dead material is removed, we may assume that the pus-producing organisms are also concerned in the process.

The following history and temperature chart represent very well a typical case of sapremia:

A. J., aged twenty-seven, had been pregnant for two months when she began to bleed from the uterus. The bleeding continued for several days, without other symptoms, when she was examined and treated by a physician. Two days later she was seized with a violent chill, followed by fever and profuse sweating, vomiting, and prostration. A second chill occurred in twelve hours, and bleeding recommenced. On the following day she was brought to the hospital by the ambulance. At this time her temperature was 104° F.; her pulse 108; she complained of headache; her face was flushed. There was a discharge of blood from the uterus of moderate quantity which gave out a faint odor of decomposition. The uterus was moderately enlarged, soft, and tender. The contents of the uterus were immediately evacuated. The contents consisted of decidual and fetal tissues in a state of decomposition. Four hours afterwards the patient's temperature had fallen to 98° F., and did not rise again above 99° F. The pulse also had fallen in sixteen hours to 72, where it remained. The patient had no further pathological symptoms.

Typical Characters of Septic Diseases.—By *septic intoxication* we understand the symptoms produced by the absorption from a focus of suppuration of the toxic products elaborated in the tissues by the pus-producing organisms. We use this term mainly for the purpose of excluding those cases in which the bacteria have entered the circulating blood in large numbers, or have caused new foci of inflammation in distant parts. By *septicemia* we understand that form of infection in which living pus microbes exist and multiply in the blood. By *pyemia* we mean that form of blood-poisoning in which the pus microbes,

having entered the blood current from a local focus of suppuration, either directly or through the medium of the lymphatic channels, are carried to and lodge in distant organs, there to form new foci of suppuration. Clinically it is not always possible to separate septicemia and pyemia. In certain cases the two coexist, and we speak then of *septico-pyemia.*

Blood Cultures in Septic Diseases.—In septic diseases of a severe grade caused by the pus-producing bacteria—i. e., in true septicemia, from whatever local lesion, and pyemia—it is possible to demonstrate the presence of one or other of the forms of pyogenic cocci in the blood in a considerable proportion of

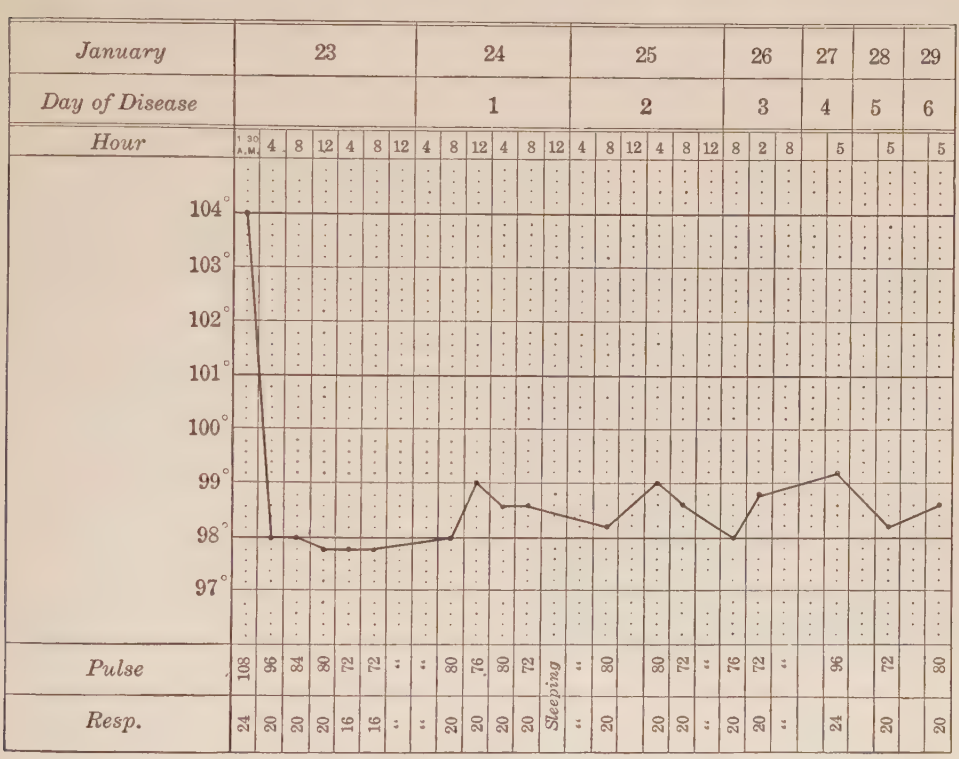


Fig. 19.—Temperature Chart of a Case of Sapremia.

cases. It was formerly believed that in septicemia blood cultures were very rarely successful, except during the last days of the disease, and that the most favorable time for making the examination was during or shortly after the occurrence of a chill. At the present time, when it is customary to use large quantities of blood for the preparation of cultures, it has been found that such cultures are successful in a large proportion, certainly more than one half, of pronounced cases of septicemia at some time during the disease, and in many instances such cultures give positive results at every trial. The test is a valuable one, since by identifying the bacteria found in the circulating blood we are able to form a fairly good idea of the prognosis. It is, for exam-

ple, well known that the presence of streptococci in pure cultures in the blood is of more unfavorable significance than is the case with most other forms of pyogenic germs. In a number of instances under my care in the New York Hospital the Staphylococcus pyogenes aureus has been demonstrated in the blood on several occasions, and yet the patient has recovered. Such has not been the case when streptococci were demonstrated. It is rarely, if ever, possible to discover bacteria in the circulating blood by cover-glass smears.

Method of Procedure in Making Blood Cultures.—The utmost care must be taken to disinfect the patient's skin at the place where the blood is to be withdrawn, and scrupulous attention should be paid to the details of aseptic technic in performing the operation. A vein at the bend of the elbow is ordinarily used as a source of the blood. The vein should be exposed through a small incision in the skin, and the blood to a quantity of at least 20 c.c. may be drawn into the barrel of a large aspirating syringe, which must be certainly sterile, through an aspirating needle thrust into the caliber of the vein; the apparatus known as Thatcher's "mosquito," or Ewing's pipette, may be used. The needle or the mosquito is thrust into the vein and the blood flows into the flask; 1 c.c. of this blood is added to 100 c.c. of broth or other fluid culture medium in a suitable flask. Three such flasks are usually prepared and placed in the incubator. Should a growth occur in the medium, the bacteria are to be identified in the pathological laboratory by the ordinary methods.

Fig. 20.—Thatcher's "Mosquito."

Septic Intoxication.—The condition of septic intoxication is, of course, present to a greater or less extent whenever an acute infection by pus-producing germs exists anywhere in the body. Septic intoxication may therefore exist of every grade of severity from the scarcely perceptible fever and *malaise* which may accompany a small and slightly infected superficial wound, or the presence of an insignificant furuncle, or a subcutaneous abscess in loose tissues, to the fulminating cases of peritoneal sepsis following the sudden invasion of the peritoneal cavity by an overwhelming dose of bacterial toxins, such as may destroy life in a few hours. The violence of the symptoms will be modified by a great variety of factors which we have considered elsewhere. In general, the intensity of the constitutional reaction is modified by the size of the dose of bacterial toxins and by the virulence of the bacteria, as well as by a number of local conditions—as, for example, the existence of tension in the inflammatory focus. A small abscess the walls of which are in unyielding tissues, so that the contained pus is in a condition of tension, may cause constitutional

symptoms of a degree of severity out of all proportion to the size of the inflammatory focus. The absorbing power of certain tissues and of the walls of certain body cavities apparently has much to do with the rapidity of the absorption of toxic products; for example, the serous membranes of the cranium and of the peritoneum, as well as the synovial membranes of joints, are known to be of a character favoring the rapid absorption of toxins.

Constitutional Symptoms of Septic Intoxication.—These consist of the symptom complex known as fever, and others. The fever is usually continuous, with remissions; lower in the morning and higher in the evening. It may be intermittent, with more or less sudden exacerbations. If the disease is to be fatal, the fever frequently shows an upward tendency, and may rise to a high degree just before death. The evacuation or removal of the inflammatory focus is, in pure septic intoxication, followed by a rapid fall of the fever. In some instances, after an abscess is opened and drained—notably if much tension has been present—the temperature will fall almost or quite to normal at once, and remain there. If the incision of an inflammatory focus has involved the opening up of many lymph spaces, a temporary increase in the fever may occur, to be speedily followed by a fall of temperature to or near the normal. The pulse is increased in rapidity. If the degree of intoxication is moderate, the pulse will be full. In more severe cases the pulse will be not only rapid, but feeble. In fatal cases the pulse will grow more rapid and more feeble and compressible until death. In general, the height of the temperature and the rapidity and character of the pulse vary together. A high temperature will be accompanied by a correspondingly rapid pulse; this relation is, however, not constant. In many sudden and severe cases, where a large dose of septic material enters the circulation, the pulse may be rapid and feeble, while the temperature is but little elevated. Such a want of correspondence between the temperature and the pulse sometimes indicates an overwhelming dose of poison, and may be of the gravest significance; it is noted especially in perforation peritonitis.

Accompanying the rise of temperature and increased rapidity of the pulse there are other and varied symptoms and signs, presently to be described. It is to be borne in mind that clinically we are not always able to separate cases of septic intoxication from those of septicemia. If, after the relief of the tension and the evacuation of an inflammatory focus by suitable means, the fever and other symptoms speedily subside and recovery takes place, septicemia did not exist. In many instances we are unable at once to fulfill perfectly the indications of drainage and the relief of tension. The symptoms persist, and we cannot at once exclude septicemia.

Septic Intoxication as the Result of Errors in Aseptic Technic.—As the result of errors in aseptic technic, cases of moderate septic intoxication are occasionally seen in surgical work. Following an operative wound upon clean tissues, a patient complains after forty-eight hours of a sense of discomfort in the wound, a sense of fullness or tension or slight pain. The

evening temperature upon the second day is 100° F.; the pulse, 86. Upon the third day the temperature in the evening is 101° F.; pulse, 95. The patient has no desire for food; he drinks much water; his tongue is coated. He is somewhat restless at night. His face is a little flushed, his eyes bright. The sense of fullness in the wound continues, but there is no severe pain. Perhaps his *malaise* and fever are attributed to autointoxication caused by imperfect action of the bowels, and appropriate means are used to cause the bowels to move freely. The temperature and pulse remain elevated, however, and the patient after a day or two more complains a good deal of pain in the wound, and begins to feel really ill. He has headache. The urine is scanty and high-colored. He has a positive distaste for food, but complains a good deal of thirst.

Upon examination the wound edges may be found reddened, swollen, and tender. The swelling has caused undue tension of the skin sutures, and the swollen skin is puckered at the sutured points. Removal of one or more sutures and separation of the wound edges permit the escape of a moderate quantity of yellow or blood-stained pus from the subcutaneous wound cavity. The exposed tissues do not appear necrotic, nor much infiltrated. Here and there at the site of ligatures a minute mass of necrotic tissue may appear as the center from which the infection started, or the walls of the punctures in the tissues occupied by sutures at one or several points may be necrotic, and infiltrated with pus. They have evidently formed the centers from which the infection started. In other cases the skin and subcutaneous tissue will be free from signs of inflammation, but pressure will elicit marked tenderness in the deeper structures. Upon opening the wound a collection of pus will be found along the suture line of the muscles. In these mild cases of infection, evacuation of the pus and relief of tension are followed at once by subsidence of all the symptoms. The wound edges become clean in a few days, and healing proceeds rapidly.

Combinations of Sapremia with Septic Infection, Saprophytic and Pyogenic Infection.—In a large number of cases combinations of pyogenic and saprophytic infections occur; the resulting local lesion and systemic poisoning may be of any possible degree of severity. Some of the more severe forms have been described under Moist Gangrene, Acute Emphysematous Gangrene, and kindred lesions. The less severe forms are very common as the result of accidental crushing injuries—such injuries, for example, as extensive contusion and laceration of the soft parts of a limb, with or without destruction of the main blood-vessels, and compound fracture of one or more bones of the extremity. A typical case of this kind is the following:

M. B., a vigorous young man of twenty-eight, who had been in perfect health, with splendid muscular development, was brought to the hospital with the following history: A short time before admission his left upper arm had been crushed in an elevator; moderate symptoms of shock; surface cool and pale; respiration sighing; temperature, 98.6° F.; pulse, 68; left arm, extensive contused and lacer-

ated wound involving the soft parts from the junction of the upper and middle thirds of the humerus down to and including the elbow. There was a compound comminuted fracture of the left humerus; the upper half of the bone was intact; the lower half, including the condyles and the olecranon process of ulna, crushed to numerous larger and smaller fragments. The left hand was pale and cold. There was no radial pulse. Amputation was refused. Cleaning and disinfection of wound, dressing and immobilization of limb under ether took place.

The following day it was evident that circulation in the hand and forearm had entirely ceased; temperature, 103.8° F.; pulse, 108. The next morning the hand and wrist were gangrenous, characteristic discoloration was present, and the wound emitted an odor of putrefaction. The upper arm was markedly swollen, and the skin showed a slight inflammatory blush extending well up toward the shoulder. An abundant discharge of thin, blood-stained fluid escaped from the wound; the odor of putrefaction was unmistakable. Temperature and pulse remained elevated. On the fourth day gangrene had extended to the elbow. There was marked cellulitis of the upper arm as far as the shoulder. The patient was much prostrated and looked severely ill. Amputation was now acceded to and was done on this day at the shoulder-joint. Of necessity, the flaps contained infected tissue; accordingly, the wound was left open and packed with gauze wet with a three-per-cent solution of aluminium acetate. Cellulitis of the skin and subcutaneous tissues of the flaps and some sloughing of the muscular flaps persisted after the amputation and moderate suppuration occurred in the wound for a number of days.

Symptoms of systemic infection continued fairly marked for two weeks and gradually subsided. The profound weakness and depression which had existed before the amputation as the result of sapremic absorption disappeared at once after the gangrenous limb was removed, and though the patient was profoundly anemic and lost a good deal of flesh, at no time thereafter did the pyogenic infection threaten to destroy his life. The accompanying chart illustrates the prompt reaction following the accident almost at once and due to sapremic poisoning. The symptoms gradually merging into those of pyogenic infection reached a climax at the end of thirteen days, when a considerable pocket of pus was discovered in the substance of the deltoid muscle and evacuated, followed by slow but continuous improvement for the following fortnight, when the wound ceased to suppurate and the septic symptoms ceased. Characteristic leucocytosis was present as long as suppuration continued. (See Fig. 21, page 94.)

Local Signs of Septic Infection.—The local symptoms vary greatly. Usually there is a wound or inflammatory focus accessible to our diagnostic methods of search; in some instances we can only surmise the point of origin of the infection. If the virulence of the poison is very great, the constitutional symptoms may come on suddenly and end in death in a few days, with trifling local evidence at the point of entrance of the poison. Such violent forms of infection are occasionally seen among surgeons and those who make autopsies upon bodies just dead of septic diseases. The prick of a needle upon the finger made during an operation upon a case of acute osteomyelitis or other intensely septic process, is followed in a few hours by a chill and a rapid rise of temperature; prostration is marked; at the site of inoculation there is to be noticed only

slight redness and tenderness, and a few faint red streaks upon the skin of the arm along the course of the lymphatic vessels; slight swelling and tenderness of the lymphatic glands of the axilla may be noticed. In the course of the next twenty-four hours the general condition of the patient grows rapidly worse, delirium follows headache, and is soon succeeded by stupor and coma. The heart beats more and more rapidly and feebly, and death occurs in a few days in collapse, without the development of any noteworthy local symptom. In such cases the lymphatics have failed to furnish an efficient barrier to the rapid dissemination of the bacteria and their poisons throughout the body.

Lymphangitis.—More commonly the local manifestations of an inoculation with pus microbes through a minute wound are more marked. In twenty-

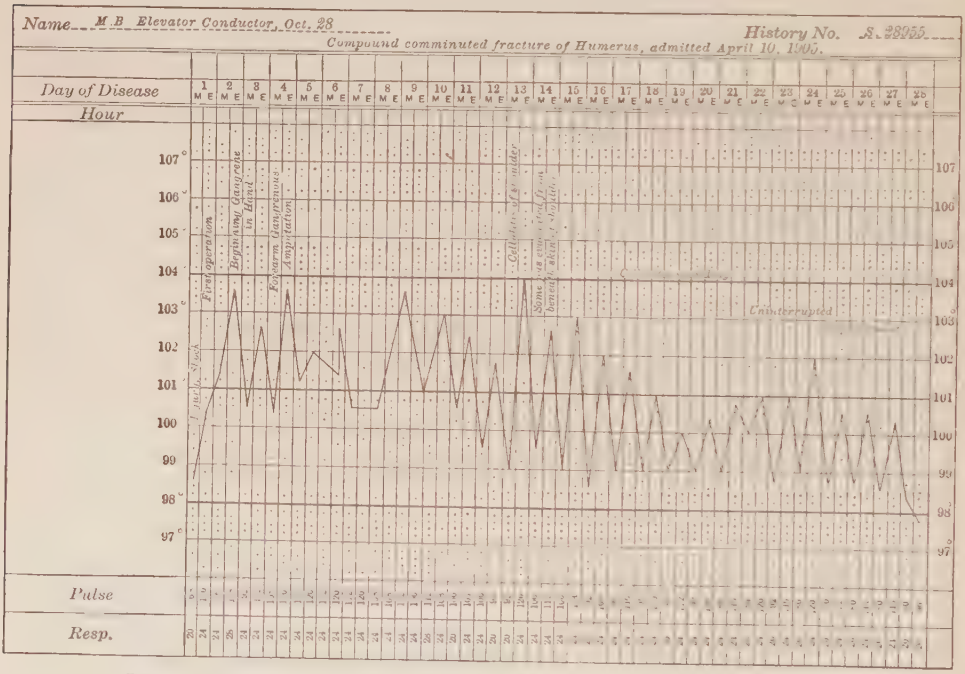


Fig. 21.—Chart of a Case of Mixed Sapremic and Pyogenic Infection.

four or forty-eight hours after the inoculation, pain, heat, redness, and swelling develop in the neighborhood of the wound. A little discharge, at first of cloudy serum, then of pus, may be evacuated from the puncture or abrasion. The patient soon begins to feel ill; a chill may occur, more often not, and there will be a rise of temperature, headache, loss of appetite, prostration. The pulse will be of a rapidity corresponding with the height of the fever, and will usually be full and bounding. If the wound be upon the hand, red, tender streaks will be noted running up the forearm and the arm toward the axilla. The axillary lymph nodes will be found tender and swollen. The epitrochlear gland at the flexure of the elbow will be found in a similar condition (Lymphadenitis). If the infection be not of too virulent a character, the process may end here, pro-

vided appropriate local treatment is pursued. The lymph nodes usually remain enlarged for some time after the acute process has ceased. In other cases the constitutional symptoms will continue, the lymphatic glands will grow larger and more tender; purulent softening of the glands will take place. If the process goes as far as this, the capsule of the lymphatic glands will usually be perforated, and periglandular infection will occur, resulting in a more or less extensive abscess of the axilla.

Such abscesses are usually not hard to recognize. The axilla is painful; motions of the arm are restricted; palpation of the axilla will show the signs of localized purulent infection. The axilla will be occupied by a tender, hard, circumscribed or diffuse swelling. The skin will be reddened if the abscess has approached the surface; otherwise, not. If the abscess is deeply seated the elastic feeling imparted to the examining fingers by collections of fluid will often be obscured by the dense inflammatory infiltration of the surrounding structures. If the abscess has approached the surface, fluctuation may be detected. The constitutional symptoms will become more severe when such an abscess forms, to be followed by rapid improvement after suitable incision for relief of tension, and drainage.

Signs and Symptoms of True Septicemia.—Very different are the signs and symptoms of true septicemia; happily, we rarely see at present grave forms of the disease follow our operative procedures upon noninfected tissues. As already described, some of the most rapidly fatal forms of the disease follow insignificant, accidental wounds. Criminal operations upon the contents of the pregnant uterus are not infrequently followed by forms of fatal septicemia of extreme violence. So, also, diseases and injuries of the abdominal viscera attended by the sudden pouring out into the peritoneal cavity of a large quantity of intensely septic material. Accidental wounds of large joints are the starting-point of many severe cases.

Septicemia and Acute Emphysematous Gangrene Produced by the Bacillus aërogenes capsulatus.—The Bacillus aërogenes capsulatus, first studied by Welch and Flexner, which is responsible for some of the most rapidly fatal cases, is an anaërobic bacillus. The individual rods measure from 3 to 6 μ in length and from 0.5 to 1 μ in breadth. The ends of the rod are square or rounded. The bacillus occurs singly, in pairs, sometimes in chains or threads. Cultures are only possible under anaërobic conditions. The colonies are gray or brownish-white in color; when viewed by transmitted light they exhibit a central darker spot. Each colony measures from 2 to 3 mm. across. Deep colonies are oval or spherical in shape, with featherlike projections. The tissues and the blood in the vessels of rabbits killed immediately after the intravenous injection of a suspension of the germs in bouillon, and kept for some hours at a temperature of 40° C., contain much gas and numerous bacilli. As originally observed and studied by Welch, the germ and its associated gas production was only found at autopsy in human beings, and was believed to be nonpathogenic for man. During the past few years, however, a number of observa-

tions have been made showing that the bacilli are capable of producing a most intense septicemia, characterized by a rapid, fatal course, by jaundice, by the production of gas in the blood-vessels and in the tissues throughout the body, and by the parenchymatous degeneration of the parenchyma of organs and of muscle fibers. In addition, the bacillus has been demonstrated as a gas producer in pneumothorax and pyopneumothorax, in peritonitis, and as an inhabitant of the bladder in pneumaturia. Further, it is observed as a cause of some cases of acute emphysematous spreading gangrene with putrid decomposition. A bacillus believed to be identical can often be demonstrated in the contents of the intestine in normal cases. It was present, apparently in pure culture, in two fatal cases of puerperal septicemia recently observed in the New York Hospital. In one of these emphysematous crackling of the subcutaneous tissues of the abdominal wall was noted before death. In the other, the characteristic appearances were only observed at autopsy. Both of these cases were characterized by an extraordinary virulence and rapidity of the infectious process. In one, death is believed to have occurred in less than twenty-four hours from the moment of infection; in the other, in two or three days. The following are short abstracts of the histories of these two cases:

Case I. *Puerperal Septicemia from Infection with Bacillus aërogenes capsulatus.*—A. O., female, aged twenty-four, was brought to the hospital in the ambulance, at ten minutes past eight in the morning, with the following history: On the day before admission an instrument had been introduced into the uterus for the purpose of inducing an abortion. A few hours afterwards she was seized with a severe chill, nausea and vomiting. Repeated chills and continued vomiting followed, and the patient became very ill indeed. During the night a physician was called who emptied the uterus, bringing away a three-months' fetus and membranes. Becoming alarmed at the very serious condition of the patient, an ambulance was sent for, and arrived about an hour after the completion of the operation. On the arrival of the ambulance surgeon, the patient was conscious. The expression of the face was anxious; pulse was rapid and weak; slightly jaundiced. There was slight bleeding from the uterus, but no history of any considerable hemorrhage. During the journey to the hospital, which consumed ten minutes, the patient became unconscious. The jaundice was more marked. Upon arrival at the hospital, patient was unconscious; deeply jaundiced; respiration stertorous; no perceptible radial pulse; temperature upon admission 101.2° F.; respiration, 40. In twenty minutes the patient was dead. Autopsy was three hours later: *rigor mortis* slight; general jaundice; general, but slight, emphysema of the subcutaneous cellular tissues; gas in the superficial veins of the arms. The peritoneal cavity contained a little gas and a small amount of bloody fluid; bloody fluid in the pleural cavities and pericardium. Heart cavities contained gas. Spleen was somewhat enlarged and soft; tissue blood-stained, containing a little gas; liver and kidneys blood-stained; blood contained a little gas; uterus enlarged and contained a blood clot. The peritoneal coat over the posterior surface of the uterus was ruptured in several places from the accumulation of gas beneath it. Microscopic examination of the tissues showed parenchymatous degeneration of all the tissues

examined. Kidneys were necrotic. Bacillus aërogenes capsulatus was identified in the blood by microscopic examination and cultures.

Case II.—M. D., female, aged twenty-six, was admitted to the hospital at noon, with the following history: Two days before admission a metal instrument had been introduced into the uterus for the purpose of bringing on an abortion. The operation was followed in a few hours by severe chills, fever, nausea and vomiting. A physician was called who advised hospital treatment immediately. On admission the patient looked profoundly septic: slight jaundice of skin and conjunctiva; temperature, 104.8° F.; pulse, 132; respiration, 64; heart and lungs negative; abdomen—liver dullness normal, no abdominal distention, marked general abdominal rigidity and tenderness; vaginal examination—cervix soft, admits one finger, body of uterus three times the normal size and soft, bloody discharge containing shreds of tissue from the cervix; active stimulation. Patient was taken to the operating room for operation two hours after admission. Palpation of the abdomen showed emphysematous crackling in the subcutaneous tissues of the abdominal wall. Palpation and percussion showed the spleen much increased in size. The patient began to fail so rapidly that no operation was attempted. The patient was put to bed at once, where she died in a few moments. Autopsy, twenty-three hours later, was as follows: moderate *rigor mortis*; general jaundice; emphysema of cellular tissues throughout the body well marked; the pleura, the pericardium, the peritoneum contained gas and bloody fluid; the gas burned with a blue flame; 300 c.c. of fluid in the peritoneum; all the tissues infiltrated with blood pigment; spleen five times its normal size; capsule dissected off the parenchyma by accumulated gas; substance of the spleen contained much gas; uterus—the veins of the uterus contained thrombi; bladder contained bloody urine. Microscopic examination showed parenchymatous degeneration of all the tissues. Bacillus aërogenes capsulatus demonstrated as in the former case.

The noteworthy characters of the disease in this case were the slowly progressive symptoms of septic poisoning, which proceeded until death, entirely uninfluenced by local treatment. It is to be noted that the leucocytosis never rose very high in spite of the severity of the septic poisoning, the percentage of polynuclears being always high after the first few days; in other words, the blood and other tissues reacted but feebly and inefficiently to stay the progress of the infection. Blood cultures, although often made, only disclosed the presence of bacteria shortly before death.

Cases of emphysematous gangrene caused by Bacillus aërogenes capsulatus have been reported by G. E. Brewer, John B. Roberts (*Annals of Surgery*, June, 1901), and others. Brewer's case was that of a woman who had had a pain in the ischiorectal region for a week before coming to the hospital for treatment; during this time she had felt ill and prostrated. On admission there were general symptoms of sepsis. Locally there was marked swelling of the vulva and ischiorectal space upon the left side. There was a superficial area of gangrene on the left labium majus. Incision revealed a condition of emphysematous gangrene of the subcutaneous tissue of the ischiorectal fossa and labium, including a very large area of the left side of the wall of the

belly. Recovery took place after extensive incisions and the separation of much necrotic tissue. Bacillus aërogenes capsulatus was identified in pure culture and by animal inoculation in the putrid fluid escaping from the wound at the time of operation and from the necrotic tissues.

Dr. Roberts's case was that of a young girl, aged twelve years, who in falling sustained a fracture of the shafts of the radius and ulna, with a very small wound in the skin created from within by the broken ulna. Three days later the patient was seen by Dr. Roberts, who found emphysematous gangrene of the forearm. The following day amputation was done through the middle of the upper arm; gangrene of the stump followed, but was controlled without further amputation. Recovery took place. The tissues and blood-vessels of the amputated limb, arteries, and veins contained gas. Pure cultures of Bacillus aërogenes capsulatus were obtained from tissues and fluids of amputated limb. In this case there were marked septic symptoms and the signs of acute nephritis.

A more common type of septicemia complicated by pyemic chills is well illustrated by the following case, in which the disease ran a rather chronic course. The *difference* between *septic intoxication* and *septicemia* is well shown. The removal of the local lesion did not affect the progress of the disease, nor avert a fatal issue.

Case III. *Subacute Septicemia and Pyemia Following Infection of the Knee-joint Secondary to Compound Fracture of the Patella from Direct Violence, with Death Sixty-three Days after the Accident.*—L. V., a vigorous young Italian, aged twenty-four, was hurt by a piece of flying iron propelled by the accidental explosion of a quantity of gunpowder. He was brought to the hospital at once by ambulance. His injury was found to be a compound fracture of the left patella, with notable contusion and laceration of the overlying soft parts. Immediate careful disinfection of wound, suture of patella, bilateral drainage of knee-joint were made. On the third day redness of wound edges was noted; sutures removed. On the fifth day there was severe pain in knee; irrigation of joint with salt solution; leucocyte count 10,000, seventy per cent polynuclears; rise of temperature to 101.5° F.; pulse, 92. The seventh day there was a rise of temperature to 104° F.; discharge from knee distinctly purulent; cultures showed pure Streptococcus pyogenes infection; incision and drainage of quadriceps bursa. From this time on the local and general conditions grew slowly worse. The knee continued to discharge pus, and the periarticular structures were gradually invaded by purulent inflammation in spite of repeated free incisions for adequate drainage. The temperature curve became of a distinctly septic type; irregular rises up to 104°–105° F. occurred, followed by a slow or rapid fall to 100° to 99° F. The pulse rate corresponded for the most part with the temperature, but as the weeks went by the pulse gradually became more rapid; the patient had no desire for food; he became weaker, pale, anemic, and emaciated. At the end of a month from the time of the injury his hemoglobin had fallen to thirty-eight per cent. At no time during his illness, until within two days of his death, was there any marked leucocytosis. The highest number of leucocytes recorded during this period was on the thirty-eighth day; it was then

16,000 with eighty per cent of polynuclears. For the most part it varied between 9,000 and 12,000. Blood cultures were made from time to time, and were always negative until two days before death, when the blood was found to contain numerous streptococci. On the thirtieth day of his illness Bacillus pyocyaneus was observed in the discharge from the knee, in addition to the streptococcus.

On the thirty-second day amputation of the thigh was made. All the soft parts below the middle of the thigh were found riddled with purulent foci. The structures entering into the knee-joint were practically destroyed by purulent softening. No improvement in either the local or general conditions followed the amputation. The amputation stump began at once to suppurate. Up to this time the patient had had no chills. Four days after the amputation the patient had a severe chill and a rise of temperature to 106° F. From this time until death irregular chills occurred, sometimes daily, sometimes every second day, with gradually increasing frequency, until a week before he died, when the chills ceased. After the amputation was done the patient's pulse was never less than 105 or 110 beats per minute, and rose to 140 or 150 during the upward excursions of the temperature. During the daytime he was apathetic and delirious at night. He became greatly emaciated and profoundly anemic. A large bedsore formed over the sacrum. A septic diarrhea developed. During the last week of his life the temperature curve was more continuous and not so high, varying between 102° and 103° F. He developed incontinence of urine and feces, and died unconscious, of exhaustion sixty-three days after the injury. No autopsy could be obtained, but during life there were no signs of metastatic abscesses. During the last three weeks of his life his urine indicated the presence of acute nephritis.

Gangrenous Appendicitis—Septic Thrombophlebitis of the Mesenteric Veins—Septic Inflammation of the Portal Vein and Secondary Abscesses in the Liver.—This is a true pyemia, which differs from ordinary pyemia only in that the secondary septic foci occur in and are usually confined to the liver. The condition is one which may follow any case of gangrenous appendicitis. Sometimes its occurrence may be predicted with probability when at the time of the operation we find not only the appendix, but also its mesenteriolum, totally gangrenous. It is sometimes possible in these cases to observe that the veins still further above are filled with infected thrombi. The condition is, in my experience, invariably fatal. In some cases, as in the one about to be described, the disease runs a stormy course from the start; in others the spread of the septic thrombi in the veins is slow and insidious. Sometimes these patients seem to be doing very well indeed; at the end of a week or ten days following the operation there will be no evidence of peritoneal irritation. The temperature may remain but slightly, or not at all, elevated during the twenty-four hours. The abdominal wound may heal. The pulse, however, does not return to normal, but remains accelerated. The abdomen may remain flat and free from tenderness, or in some cases there may be an accumulation of a small amount of serous fluid in the abdominal cavity; but instead of getting well, these patients continue to look ill. They are not able to eat well. They become markedly anemic. The skin is often a little jaundiced. The liver

may remain normal in size, or may project to a moderate extent below the free border of the ribs. After two or three weeks these patients will complain of a little pain and tenderness over the right lobe of the liver. If aspirating needles are thrust into the substance of the liver, it is usually possible, after repeated trials, to withdraw a little pus containing shreds of broken down liver tissue. In some cases disseminated abscesses of considerable size will be formed in the liver substance; in some, subphrenic abscess may develop; in others, the patient will become dull and apathetic, and become weaker and weaker, and finally die of exhaustion due to septic absorption and to disturbances in the function of the liver; and at the autopsy the branches of the portal vein in the liver will be found filled with septic thrombi, and surrounded by areas of purulent softening and necrosis of liver tissue. Empyema by extension through the diaphragm or subphrenic abscess may complicate the condition. Recent observations indicate that septic inflammation of the mesenteric and portal veins with liver pyemia, or more rarely with the production of one or more large abscesses in the liver, may appear long after an attack of appendicitis appears to be cured, or may follow weeks or even months after an operation for gangrenous appendicitis; and further, that it is quite probable that septic abscesses in the liver occurring without apparent cause may be due to infection through a minute ulceration in the mucous membrane of the appendix so small as never to have been recognized by its symptoms.

The following case illustrates a gangrenous appendicitis complicated by septic thrombophlebitis of the portal vein and typical symptoms of an acute pyemia, with death from exhaustion on the twenty-fourth day:

S. N., forty-two years of age, a man of large, fine physique and of exemplary habits, was admitted to the hospital with the following history: The day before admission he had been suddenly seized with the symptoms of acute appendicitis. Twenty-four hours after the beginning of the attack his temperature was 99° F. and his pulse 80. He had a leucocyte count of 15,000 with ninety-three per cent of polymorphonuclear cells. The local signs and symptoms of acute appendicitis were well marked. Upon opening the abdomen, a very little clear fluid escaped. The appendix was large, situated close to the anterior abdominal wall; the entire appendix, including its mesenteriolum, was gangrenous. There were some slight adhesions around the appendix; upon separating these a small abscess was opened containing about two drachms of very foul-smelling, dirty, greenish-brown pus. Removal of gangrenous appendix with its mesentery was made; cleaning of the structures in the vicinity; drainage with a large gauze wick wrapped in rubber tissue; abdominal wound left largely open. The patient's temperature rose at once to 105° F., with a corresponding acceleration of pulse rate. Exploration of the wound upon the following day showed the entire wound surface as far as the skin gangrenous. All sutures were removed; wound washed with peroxide and salt. A little thin, greenish, foul pus escaped upon withdrawing the drain, but there was no evidence of an extension of the process in the peritoneal cavity. Upon the third day the patient had a chill and a rise of temperature to 106° F., and for the first time he began to look and feel severely ill. These chills and corresponding rises

of temperature recurred daily, or every other day, until the end of two weeks, when they ceased. They were followed by profuse sweats, marked prostration, and a sudden fall of temperature of five or six degrees. During all this time the patient's pulse remained of fair quality, but always a little more accelerated from day to day. The patient did not complain of abdominal pain; he continued to take a sufficient quantity of food; he had no diarrhea. On several occasions he was put under the influence of chloroform and the peritoneal cavity carefully explored for secondary foci of inflammation; none were found. In the mean time the condition of the abdominal wound had so far improved that all appearance of necrotic or gangrenous inflammation had disappeared. The wound surfaces became clean, and the coils of intestine at the bottom of the wound looked smooth and fairly healthy. Only a little thin, purulent discharge could be removed from the site of the base of the appendix at the daily dressing.

It was noticeable, however, that no effort whatever was being made by the tissues toward healing; no granulations were formed; the wound edges remained pale, and did not bleed upon manipulation. The general condition of the patient grew steadily worse. He began to be very pale; his face had an anxious expression; dark hollows formed beneath his eyes; his tongue was coated; his forehead was often bathed in a clammy sweat. Following the chills his physical and mental distress were pitiable. At the end of two weeks the condition of his abdominal wound remained unchanged, except that the amount of the discharge was reduced to a very little, and that of a serous character. His mind wandered a little in the daytime; at night he was distinctly delirious. He no longer took his food well, and had to be urged to swallow it. The degree and character of the leucocytosis continued about the same. Blood cultures were negative. Upon the sixteenth day he began to complain of pain and tenderness over the right lobe of the liver. The liver percussed a little large. On the eighteenth day an aspirating needle thrust into the substance of the liver withdrew from various situations a few drops of brownish material, found under the microscope to consist of necrotic liver tissue and of pus. No more chills occurred after the fifteenth day. The temperature curve assumed a more continuous type, and varied from 102° to 105° F., with a steadily increasing acceleration of pulse rate. He became a little jaundiced. His mental condition became more and more confused and dull. He suffered from dyspnea. The physical signs of bronchitis, merely, were present in the chest. Slowly, but steadily, the symptoms of exhaustion ensued, and he died on the twenty-fourth day of the disease. An autopsy was not permitted. He did not develop a septic diarrhea, nor were the signs and symptoms of nephritis present.

Special Groups of Symptoms in Septic Infections.—In cases of septic infection certain signs and symptoms are present indicating disturbances of certain organs or groups of organs. They are not peculiar to these forms of infection, but yet form an essential part of the clinical picture. We have already indicated the disturbances of the heart and the temperature, and may now consider the disturbances of the alimentary canal.

Alimentary Canal.—The appetite is usually diminished or lost. The power of digesting food is more or less seriously impaired, according to the intensity of the poison. In nearly all cases of severe septic intoxication, except

those which involve an inflammation of the peritoneum or an obstruction to the alimentary canal, diarrhea is present at some time during the disease; if severe, and uncontrollable by careful regulation of the diet, it is a symptom of serious import. The stools are often very offensive. The catarrhal condition of the intestine may be accompanied by ecchymoses into the mucous membrane and by hemorrhages. Ulcers resembling those of dysentery may occur. Many cases of septic intoxication are accompanied by vomiting. The vomiting may occur during the onset of the disease, as is so commonly the case with acute inflammations of the peritoneum, or it may develop later when the vital powers of the patient are greatly depressed, and is then of unfavorable import.

Nervous System.—The nervous system is always more or less profoundly affected. Many cases of severe septic intoxication are ushered in by a chill. Headache is commonly present when the temperature is elevated above 102° or 103° F. In more severe cases the headache in the daytime alternates with delirium at night. In fatal cases stupor and coma follow the delirium, and persist until death.

Heart and Lungs.—*Pericarditis* and *pleurisy*, either sero-fibrinous or purulent, are occasional complications, and give rise to characteristic signs and symptoms.

Bronchitis and *pneumonia*, usually of the lobular variety, are fairly common complications, and are to be recognized by the cough, expectoration, and the physical signs.

Kidneys.—The function of the kidneys is disturbed. The quantity of urine is diminished; the urine is of a high specific gravity and dark in color. In severe cases an acute exudative nephritis may develop, with the presence of albumin in the urine, together with casts containing blood cells. In some cases a true hemorrhagic nephritis occurs, with more than a microscopic amount of blood in the urine. The urine may contain numerous living pyogenic microbes. In fatal cases cloudy swelling or parenchymatous degeneration of the renal epithelium is present—most marked in the glomeruli. In very chronic cases waxy or amyloid degeneration of the kidney may occur. The capillaries of the glomeruli may contain numerous bacteria.

Spleen, Liver, and Skin.—The *spleen* is usually enlarged in septicemia, and after death may be softened and show the lesions of parenchymatous degeneration. The *liver* is often enlarged, and in a similar condition of degeneration. The jaundice which sometimes accompanies severe forms of septicemia is due to disintegration of the red blood cells and liberation of the pigment. Various *skin lesions* may accompany septicemia; urticaria, erythema, papules, pustules, and blebs are not infrequent. Sometimes the skin eruptions may resemble those of scarlet fever or measles. During the earlier stages of septic fever, *sweating* is often a marked symptom, especially after a sudden fall of temperature; the sweat sometimes has a sour odor. If the disease exists for some time, the skin becomes harsh, dry, and scaly.

The Blood in Septic Processes.—The red blood cells are rapidly destroyed in all generalized septic processes—septicemia and pyemia. The anemia continues to increase as long as the infection endures, and may reach a profound degree in a short time. Not only the number of red cells is diminished, but also the percentage of hemoglobin. It has been noted, for example, in many instances, that the number of red cells were reduced to 2,000,000 and even lower, and the hemoglobin may be diminished to thirty, or even twenty per cent. This rapid blood change is far less marked in localized suppurative affections where the degree of intoxication is not marked, and where no general invasion of the organism by pus microbes has taken place. Nucleated red cells are occasionally observed in septic processes, but not in large numbers.

Chronic suppuration induces anemia, with diminution of red cells and of hemoglobin. For example, in a case of suppurating sinuses of the thigh leading to dead bone, which had existed for three years, I found the red cells diminished to 2,300,000, and hemoglobin to thirty per cent. Suppuration had been fairly active during this period. If the amount of suppuration be small, the blood changes are not marked. Changes in the shape and diameter of red blood cells are sometimes seen in severe septic processes which have existed for some time. The red cells are diminished in diameter, and may show granular degeneration.

Leucocytosis.—Suppurative processes are usually accompanied by an increased number of leucocytes in the blood. Leucocytosis is sometimes absent in

	Approximate Differential Count of Leucocytes in—							
	Normal Blood.	Chlorosis.	Secondary Anemia.	Pernicious Anemia.	Acute Lymphatic Leukemia.	Chronic Lymphatic Leukemia.	Myeloid Leukemia.	Inflammatory Leucocytosis.
Small Lymphocyte.....	28%	35%	38%	42%	4%	88%	8%	28%–2%
Large Lymphocyte.....	6%	6%	6%	4%	90%	5%	3%	6%–1%
Polynucl. Neutrophile...	65%	58%	55%	50%	4%	7%	30%	65%–95%
Eosinophile.....	1%	1%	1%	3%	0.5%	0.2%	6%	1%
Basophile.....	0.2%	0.2%	0.2%	0.2%	None	None	0.2%	0.2%
Myelocyte.....	None	None	None	1%	2%	None	45%	None
Eosinoph. Myelocyte	None	None	None	None	None	None	8%	None

A purulent process increases the percentage of polynuclear cells in inflammatory leucocytosis.

Fig. 22.—Sondern's Table of Differential Leucocyte Counts.

asthenic types of septicemia; the number of leucocytes in the blood may be subnormal. Local suppurative processes are commonly attended by a leucocytosis whose grade is in proportion to the intensity of the inflammation and to the reaction of the organism against the invasion of the pus-producing germs. Purulent collections of small size, if under much tension, are often accompanied by a high leucocyte count. The leucocytosis of local processes usually

lasts as long as the inflammatory exudation continues, or until the condition is relieved by operation, when it will suddenly or gradually decline. Purulent inflammations of mucous membrane are not usually attended by a marked increase in the number of leucocytes. *In the leucocytosis of purulent inflammation the polynuclear forms of white cells show the most notable increase.*

The Diagnostic Value of Leucocytosis.—This varies a good deal in different types of purulent inflammation. In local processes a steady increase in the number of leucocytes usually indicates a spreading of the lesion, and a sudden increase sometimes indicates that new areas have suddenly become infected, as, for example, from the perforation of a gangrenous appendicitis and commencing peritonitis. Absence of leucocytosis does not, as above indicated, exclude the presence of septicemia, and leucocytosis may exist in a large number of pathological conditions other than suppurative processes. Hence, the value of the leucocyte count in differentiating between obscure foci of suppuration and certain other conditions may be great or small in the individual case. For example, acute appendicitis, attended by abscess, gangrene, or purulent peritonitis, is almost always attended by marked leucocytosis; typhoid fever, unaccompanied by suppurative complications, is not. It may occasionally happen that confusion will arise in the early stage of typhoid, with marked tenderness in the right iliac fossa, between this disease and appendicitis. Absence of leucocytosis enables the observer to exclude appendicitis of the above-mentioned types; not, however, simple catarrhal appendicitis, nor yet the sudden violent cases of peritoneal sepsis from perforation, nor the asthenic types of the disease, for in the two latter leucocytosis may be absent.

The following description of leucocytes is quoted by permission from Ewing:

The Leucocytes and Leucocytosis.—Morphology of Leucocytes.—In *fresh blood* leucocytes are colorless, rather highly refractive bodies, usually larger than red cells, cohering to one another and to the glass, and exhibiting a highly refractive, compact, or, in the large mononuclear cells, vesicular nucleus. *Granules* are invisible in the normal mononuclear cells of the circulation, but in the others minute opaque (neutrophile) granules are distinctly apparent in the polynuclear cells, and large greenish refractive granules serve to fully distinguish the eosinophile cells. The protoplasm of the mononuclear cells is homogeneous, and refractive in the lymphocytes, transparent in the large mononuclear. *Ameboid motion* begins promptly, especially on a warm stage, in the finely and coarsely granular cells, becomes most active usually after twenty to forty minutes, and may persist for hours. In some later stages of ameboid activity the granules may show extremely active, vibratory, dancing, and swarming movements in cell bodies or processes. These have been regarded as Brownian movements or as indicating structural changes of approaching death of the cell. In many cells, especially in anemic blood, there appear from the first large and small clear spheroidal areas which on staining appear to be divided

among watery vacuoles, or granules of fat, glycogen, or other degenerative products.

Varieties of Leucocytes.—In *stained specimens* five varieties of leucocytes may be distinguished, viz.:

1. Lymphocytes.
2. Large mononuclear leucocytes.
3. Polynuclear neutrophile leucocytes.
4. Eosinophile leucocytes.
5. Mast-cells.

1. *Lymphocytes* are classed as (*a*) *small* and (*b*) *large*, the small cells being 5 μ to 8 μ in diameter, and the large ones 8 μ to 10 μ. Both sizes exhibit a narrow rim of strongly basophile homogeneous or coarsely reticulated cytoplasm, and compact or coarsely reticulated spheroidal nuclei, which are usually less basophilic than the cytoplasm. With ordinary stains these cells fail to show cytoplasmic granules, although exhibiting nodal thickenings of the cytoreticulum which sometimes resemble granules. After the Nocht-Romanowsky stain all lymphocytes usually show a variable number of large and small violet-stained granules, and in some of the larger cells the number of these granules approaches that of the myelocyte. The nuclei of lymphocytes usually contain nodal thickenings resembling nucleoli. While the nuclei of lymphocytes are usually spheroidal, there occur in normal blood, and especially in lymphemia, medium-sized, strongly basophilic, hyaline leucocytes with incurved or subdivided nuclei, which must be classed with lymphocytes.

2. *Large mononuclear leucocytes* may be only slightly larger than lymphocytes, but many of them are the largest cells seen in normal blood. Their protoplasm is *slightly basophilic* and *very finely reticular*, with nodal thickenings often resembling basic granules, while other cytoplasmic granules are usually demonstrable by the Nocht-Romanowsky method. Their nuclei are *vesicular*, rather coarsely reticulated, with one or two central nodal thickenings resembling nucleoli, but no true nuclei have as yet been demonstrated in these cells. The nuclei may be circular, or horseshoe-shaped (transitional leucocytes), or elongated. In Ehrlich's triacid solution the bodies of mononuclear basophile cells stain very faintly red.

3. *Polynuclear leucocytes* are two or three times as large as the red cell. Their protoplasm is reticulated and possesses as integral parts of the reticulum protoplasmic neutrophile granules in considerable number. The reticulum is otherwise very slightly basophilic, and may be demonstrated, with basophilic nodal thickenings or granules, by methylene blue. Their nuclei are elongated and constricted, or composed of two or more lobes usually connected by threads of chromatin. These lobes are coarsely reticulated, and usually possess a central nodal thickening, but true nucleoli have not been demonstrated. The lobes may become completely separated from each other.

4. *Eosinophile leucocytes* vary in size from that of lymphocytes to that of polynuclear leucocytes. Their protoplasm contains large, strongly acidophile granules which are believed to be integral parts of a cytoreticulum (Heidenhain, Gulland). Their nuclei are coarsely reticulated and usually bilobed, the lobes are more often separate than in the neutrophile cells, and they stain rather faintly with nuclear dyes.

5. *Mast-cells* are mononuclear or polynuclear cells of different sizes, whose characteristic feature is the presence of large and small strongly basophile granules. These granules do not reflect the pure color of many stains, but are *metachromatic*, especially with thionin. A few mast-cells are always to be found in normal blood, but when present in any considerable numbers they are pathognomonic of myelogenous leukemia. Levaditi describes small acidophile granules in mast-cells. The mast-cell of the blood is entirely different in appearance from the mast-cell of the tissues.

Leucocytes in Pathological Blood.—Besides the above forms of colorless cells which alone are present in normal blood, other types of cells are seen in the circulation in disease.

Myelocytes are mononuclear cells with neutrophile or with eosinophile granules. Three types of myelocytes should be distinguished:

(*a*) *Ehrlich's myelocyte* is a medium-sized cell with pale, usually central nucleus, and neutrophile granules. It is found in many morbid conditions, especially in leukemia and secondary anemia. Ehrlich has described as "neutrophile pseudolymphocytes" very small myelocytes with densely staining nuclei, which were seen in hemorrhagic small-pox.

(*b*) *Cornil's myelocyte* is a large cell, much larger than a polynuclear leucocyte, with pale eccentric nucleus and neutrophile granules. It is found almost exclusively in myelogenous leukemia, and less frequently in v. Jaksch's anemia.

(*c*) *Eosinophile myelocytes* may resemble the eosinophile cells of normal blood, except that their nuclei are single. Such cells are abundant in myelogenous leukemia, occur not infrequently in v. Jaksch's anemia, and have been found in myxedema by Mendel, in some infectious diseases by Turck, and in pernicious malaria by Bignami. Or their granules may be of excessive size, in which case they are pathognomonic of myelogenous leukemia. Most myelocytes possess true acidophile nucleoli (Jolly).

Classification of Leucocytes.—Although the leucocytes were discovered by Nasse in 1835, the first scheme of classification based upon their supposed points of origin was offered by Virchow, who divided the colorless cells into *lymphocytes* derived from the lymph nodes, *splenocytes* from the spleen, while polynuclear cells he regarded as developmental forms of the mononuclear. Similarly, Einhorn, a pupil of Ehrlich, classed the leucocytes as: (1) lymphocytes, small and large, derived from the lymph nodes; (2) myelogenous cells (eosinophiles) from the marrow, and (3) large mononuclear, transitional, and polynuclear cells, from spleen or marrow.

In 1865 M. Schultze described the leucocytes as (1) nongranular (large

and small mononuclears); (2) finely granular (neutrophiles), and (3) coarsely granular (eosinophiles and mast-cells). He believed that all granules and cells represent developmental forms of one series.

Lowit's classification, based on the morphology of the nucleus, included small and large mononuclear cells (lymphocytes), "transitional" leucocytes, and polynuclear leucocytes. Regarding solely the nucleus, Lowit found no difficulty in deriving all leucocytes in one series of cells. It remained for Ehrlich to establish the essential distinction between leucocytes by demonstrating specific microchemical reactions in the granules of Schultze.

Ehrlich divided the anilin dyes into three main groups: (1) Basic dyes, as hematoxylon, methylene blue, thionin, etc., act as bases, uniting, with selective power in the order named, with the acid principles of cells (nucleinic acid). (2) Acid dyes, as eosin, fuchsin, aurantia, act as acids, and unite with the basic principles of cells. (3) Neutral dyes. When certain basic and acid dyes are mixed a compound is formed of modified staining qualities which unites with certain cell structures not readily stained by other methods. Such a mixture Ehrlich calls a *neutrophile stain*, an example of which is the triacid mixture. Neutral red seems also to fall in this class.

According to their reactions to these dyes the granules of leucocytes in human blood may be divided into three main groups, basophile, acidophile (oxyphile), and neutrophile, and on these grounds the present classification of leucocytes is based, as follows:

1. *Basophile Cells: Mast-cells* (*γ-granules*). Granules strongly basophile. *Lymphocytes.* Protoplasm strongly basophile. *Large mononuclear leucocytes.* Protoplasm slightly basophile.

2. *Neutrophile Cells: Polynuclear leucocytes.* Neutrophile (ε) granules. *Myelocytes.* Neutrophile granules.

3. *Eosinophile Cells: Eosinophile leucocytes.* Large acidophile granules (*α-granules*). *Eosinophile myelocytes.* Large acidophile granules.

Ehrlich also described β-granules which are amphophile, stain by both basic and acid dyes, and are found in some marrow cells, and δ-granules which are small basophile granules said to occur in some mononuclear cells.

In estimating the leucocytes in both health and disease one is confronted by a great variety of disturbing factors, including the causes of distinct physiological leucocytosis, the individual peculiarities of the subject, and the ordinary variations in the local condition of the part from which the blood is taken. All that has been said regarding accidental variations in red cells applies equally to leucocytes, and one must carefully consider the effects of vasomotor phenomena, of changes in the volume of plasma, and of the presence of inflammation or edema. It should be remembered that while the leucocytes remain nearly uniform in the great vessels, their proportions in the capillary circulation may change more rapidly than those of the red cells, owing probably to chemotactic influences. The most common sources of error may be avoided by taking specimens about four hours after a meal and at the same hour each day.

Proportions of Various Forms of Leucocytes.—The proportions of the different forms of leucocytes in normal blood are even less fixed than their numbers. Ehrlich's figures may well serve as a standard for healthy adults.

Lymphocytes, twenty-two to twenty-five per cent.
Large mononuclear and transitional leucocytes, two or four per cent.
Polynuclear neutrophile leucocytes, seventy to seventy-two per cent.
Eosinophile cells, two to four per cent.
Mast-cells, one half to two per cent.

The chief variations from these limits which deserve mention are the maximum percentages given by Rieder for lymphocytes (thirty per cent) and by Limbeck for polynuclear leucocytes (eighty per cent). In childhood the proportion of lymphocytes is usually much increased (fifty-five to sixty-six per cent), and that of polynuclear cells correspondingly diminished (twenty-eight to forty per cent). (Gundobin, Rieder.)

The following description of the method of estimating the number of leucocytes in the blood is also quoted from Ewing ("Clinical Pathology of the Blood," second edition, 1903, page 41 *et seq.*):

The Estimation of Leucocytes.—The leucocytes may be counted by a method which requires a special mixing pipette, yielding a dilution of blood in the proportion of 1:10, and a diluting fluid (three per cent acetic acid, tinged with gentian violet) which dissolves the red cells, leaving only the stained leucocytes to be counted. The same chamber is used as for counting red cells, and the same procedure is followed. All the leucocytes in 1 sq. mm. having been counted, the result is multiplied by 100, giving the number of leucocytes per cubic millimeter. The disadvantages early recognized in this method are the expense and inconvenience of an extra pipette, and a second diluting fluid, the time required in preparing a second specimen, the larger quantity of blood required, the difficulty sometimes encountered in distinguishing leucocytes from the detritus of red cells, and the impossibility of separating and evenly distributing the cohesive leucocytes.

This method has gradually been replaced to a large extent by the practice of counting leucocytes in the same specimen prepared for counting the red cells. In 1892 the writer found that he secured more uniform results with the latter method, and has since found no inducement to return to the former.

The Counting of Leucocytes in the Same Preparation with the Red.—This method requires the *Zappert Chamber*, which was originally devised by Elsholz for the estimation of eosinophile cells in fresh blood. Various modifications of the ruling in this chamber have been employed, one of which, made by Leitz, at the writer's suggestion, is represented in Fig. 13.

With this chamber, using a Leitz lens No. 7, it is possible to count over 9 sq. mm., which gives almost as many leucocytes as are counted in the other method. When the leucocytes are normal or reduced in number, it is necessary to count all there are in the available 9 sq. mm., and if the number is very low it is advisable to

prepare a second specimen in the chamber and count the white cells in 18 sq. mm. When the leucocytes are increased, 9 sq. mm., or in cases of leukemia, 6 sq. mm., will yield a number large enough to insure an accurate result.

In order to make the leucocytes visible, *Toisson's fluid* or other solution should contain enough methyl violet to stain these cells distinctly. With a little practice the eye very readily picks out the bluish, highly refractive leucocytes.

What has been said regarding the condition of the local circulation, and the effects of pressure in expressing the blood, is to be specially emphasized when estimating the number of leucocytes in a specimen of blood.

Computation.—Divide the number of leucocytes counted by the number of square millimeters traversed in the count and multiply by 1,000. The result is the number of leucocytes per cubic millimeter of blood.

If the original dilution is 1:200, which ought not to be employed except in cases of leukemia, the multiplier is 2,000. Thus if 54 leucocytes are counted in 9 sq. mm. (dilution 1:100), the number per c.mm. is 6,000 ($54 \div 9 \times 1{,}000$).

The Enumeration of Eosinophile Leucocytes.—(a) *In the Same Preparation with the Red Cells.*—When the blood is diluted, 1:100, with 0.6 per cent salt solution tinged with gentian violet, the leucocytes retain their natural size and shape and eosinophile cells can be readily identified by their large, greenish, refractive granules. In cases of myelogenous leukemia this method is satisfactory, but when the eosins are present in their usual numbers (one to five per cent), one must count a larger number than can be found by this method. The usual expedient is to estimate their percentage from a dried specimen of blood, and then to calculate their number from the total number of all leucocytes counted by other methods. Thus, if the count shows 12,000 leucocytes per cubic millimeter, and the dried blood slide shows two per cent of eosins, their number will be 240 per cubic millimeter. This method is sufficiently accurate for clinical purposes.

(b) *By Means of Thoma's Special Pipette for the Enumeration of Leucocytes.*—Klein, Mueller and Reider, and Elsholz have employed methods for the accurate estimate of eosinophile cells adapted to finer clinical work and to experimental research. They use the large pipette of Thoma, which gives a dilution of 1:10. The capillary tube is filled with blood to the mark 1, and the bulb is half filled with the following solution: watery eosin (two per cent), 7 c.c.; glycerin, 45 c.c.; aq. dest., 55 c.c. After shaking three to four minutes the bulb is filled to the mark 2 with the following staining fluid: aq. dest., 15 c.c.; gentian violet, conc. aq. sol., 5 drops; alcohol, 1 drop.

In specimens thus prepared, both neutrophile and eosinophile leucocytes are readily distinguished, the eosinophile cells being particularly brilliant. The red cells are dissolved and the leucocytes concentrated so that a sufficient number of eosinophile cells may be counted.

Zappert's extensive studies of eosinophile leucocytes were conducted with specimens diluted in the large pipette of Thoma, by the following solution: one per cent osmic-acid sol., 5 c.c., to which are added 5 drops of a filtered mixture (aq. dest., 10 c.c.); glycerin, 10 c.c.; one per cent watery eosin, 5 c.c.

The Histological Examination of Blood (Ewing).—The greater part of the examination of blood is conducted with dry stained specimens. To prepare such specimens for staining one requires only polished glass slides and a Bunsen gas burner. The glass slides must be thoroughly cleaned with soap and water,

dried, and kept free from dust. Passing them a few times through a flame facilitates the even spreading of the cells.

A rather small, compact drop of blood expressed from the finger tip under the usual precautions is lightly scraped off with the polished edge of one slide and applied to one end of a second slide which should lie on firm support. When the blood has spread along the edge of the smearer it should be slowly and firmly drawn over the surface of the receiving slide. The drop should, if possible, be small enough to be exhausted in the smearing, and the thickness of the layer can be fully controlled by the degree of pressure. The blood should be pushed before the smearer and not trailed after.

Many prefer to use cover-glasses in spreading the blood. One polished cover-glass is touched to the drop of blood and applied to a second cover, all corners projecting. When the blood has spread to the edges, the cover-glasses are gently spread apart without pressure. The cover-glasses should be handled with forceps, otherwise the moisture of the finger will often crenate many cells.

The writer prefers to use glass slides, finding that beginners are much more successful with the slides than with cover-glasses; that, after very little practice, every specimen can be spread successfully; that forceps are not required; that slides may be handled and transported without fear of breakage; that they need not be mounted, and, therefore, do not fade like cover-glass specimens, which require mounting in balsam; that they may safely be *fixed* in the free flame.

After spreading, all specimens should be well dried in the air. They may then be kept for weeks if wrapped in tissue paper and kept from moisture, but it is better to *fix* them at once.

Fixation—1. *Heat.*—In routine work one may discard all other methods for that of *fixation in the free flame of a Bunsen burner.* The slide, specimen side up, is passed slowly through the flame until it is decidedly too hot for the hand to bear. At this temperature, which probably varies between 110° and 150° C., fixation is complete in one to two minutes.

A little practice will give the confidence necessary to heat the slides hot enough, as one's initial failures from this method almost always result from incomplete fixation and subsequent vacuolization of the red cells. Overheated slides can usually be seen to change color in the flame, after which the red cells stain yellowish with eosin. The beginner is strongly recommended to perfect himself in this simple method of fixation.

Small ovens provided with a thermometer are made for the fixation of blood slides, and may be used when many specimens are in hand, or when one does not care to risk the free flame. Specimens should be exposed five to ten minutes to a temperature of 110° to 120° C.

2. *Alcohol.*—Fixation for ten to thirty minutes in ninety-seven per cent alcohol, or in equal parts of alcohol and ether, is a very reliable method in general use. Specimens may be left in alcohol twenty-four hours, but do not then stain quite so well. There appears to be no advantage in adding ether to the alcohol, which even without mixture with the more volatile agent must frequently be replaced. Methyl alcohol fixes much more rapidly than ethyl, requiring only one to two minutes. It may be advantageously employed as a routine fixative, and it is used as a combined fixative of blood and solvent of dyes in Jenner's and Goldhorn's

stains. Fixation in alcohol is to be specially recommended for the malarial parasite, but is unsatisfactory when Ehrlich's triacid stain is to be used.

3. *Fixation by Vapors.*—Specimens may be fixed by being laid, specimen side down, over a wide-mouthed bottle containing twenty-five per cent formalin, to which the exposure is five minutes, or two per cent osmic acid, to which expose two minutes. Both these fluids have to be replaced frequently, they considerably alter the staining relations of the blood cells, and are inferior to other methods of fixation.

4. *Fixation without Drying.*—Jolly and others claim that fixation after drying destroys many of the essential characters of leucocytes, which may be demonstrated in specimens fixed while moist in solutions of chromic acid. Flemming's stronger solution gave the best results in Jolly's hands (one per cent chromic acid, 15 parts; two per cent osmic acid, 4 parts; glacial acetic acid, 1 part). Other fixatives recommended for the same purpose are saturated bichlorid in 0.6 per cent salt solution (Hermann's fluid). All these fixatives undoubtedly give better demonstration of nuclear structures and mitotic figures than can be obtained after fixation with drying.

Methods of Staining Dry Blood Specimens.—1. *Eosin and Methylene Blue.*—The solutions required are: a saturated alcoholic solution of Ehrlich's blood eosin; a saturated watery solution (one per cent) of Ehrlich's rectified methylene blue. The latter should be at least one week old, as fresh solutions lack selective quality and stain the specimen diffusely. After several weeks methylene blue in solution diminishes in staining power, while the alcoholic eosin absorbs water, and becomes less selective and more powerful.

In staining, flood the specimen with eosin for a few seconds and wash in water. If the stain is not effective add more eosin, but the water on the slide dilutes the alcohol and renders the second application of eosin much more powerful than the first. Next flood the specimen repeatedly for one minute with methylene blue, wash hastily in water, and dry.

This method may be recommended for all ordinary examinations. The blood is stained, thus readily distinguishing the various forms of normal leucocytes. It does not stain neutrophile granules in leucocytes unless the action of eosin has been prolonged, in which case the neutrophile leucocytes can be distinguished from the eosinophile only by the size of the granules. Its chief advantage is the clear differentiation of basophilic leucocytes and of nuclear structures. It clearly demonstrates the malarial parasite, but in this field is greatly inferior to Nocht's method. Its chief disadvantage is the danger of overstaining with eosin, which prevents the full action of methylene blue.

2. *Ehrlich's Triacid Mixture.*—This fluid has the following composition:

Saturated watery solution of orange G	120–135 c.c.
Saturated watery solution acid fuchsin	80–165 c.c.
Saturated watery solution methyl green	125 c.c.

To these add:

Aqua	300 c.c.
Absolute alcohol	200 c.c.
Glycerin	100 c.c.

The attempt to prepare this mixture is not always successful. The smaller quantities of orange G and acid fuchsin are best employed, and the solution of methyl green, well seasoned, should be added slowly, with stirring, to the mixture of the other dyes. The water should be added next, then the alcohol, and, finally, the glycerin, with constant stirring. After standing one week the mixture is ready for use. Grübler's preparation of this mixture is in the market and is reliable.

In staining it is only necessary to flood the specimen with the dye for one to two minutes, and wash hastily in water. It cannot overstain, but overheated specimens are usually faint, and the red cells are yellowish. It stains neutrophile and eosinophile granules deep red, the latter being distinguished by their size. It is, therefore, indispensable in the diagnosis of leukemia. It is a poor nuclear stain, fails to demonstrate the structure of normal mononuclear leucocytes, and does not stain the malarial parasite. On account of the uniformity of its results many prefer it to eosin and methylene blue as a routine method.

3. *Jenner's Stain.*—Jenner's method of fixing and staining blood has now withstood sufficient trial to warrant its acceptance as one of the most important recent methods in blood technics. The specimens are fixed and stained in the same solution, which is prepared as follows: equal parts of 1.2 per cent to 1.25 per cent of watery solution of Grübler's yellow water-soluble eosin and of one per cent watery solution of Grübler's medicinal methylene blue are mixed together in an open basin, thoroughly stirred, and allowed to stand twenty-four hours. The mixture is then filtered, dried in the air, or oven, at 55° C., the filtrate powdered, shaken up with distilled water, and washed on a second filter. It is again dried, powdered, and stored in bottles for use. The stain is prepared by dissolving 0.5 gm. of the powder in 100 c.c. pure methyl alcohol (Merck's "for analytical purposes").

Very thin smears of blood, made on thoroughly clean slides, are dried in the air. The dye is poured on the specimen, and staining is complete in one to three minutes. The specimens are washed, preferably in distilled water, until of a pink color, which usually appears in ten seconds. All the cells, their nuclei, and the various granules are well differentiated, while the malarial parasite is densely stained and only in the larger parasites does the chromatin fail to appear deeply red stained. For this last purpose the method is inferior to Nocht's. The powder or fluid dye may be obtained from New York dealers.

Normal Variations of Leucocytes.—In health the number of white cells in the blood varies within wide limits from a variety of causes. The number is higher in the new-born than in adults, greater after the ingestion of food, greater during pregnancy. In the healthy adult, the number may vary in different subjects and at different times—according to Rieder, between 9,600 and 4,200. Still wider variations occur, according to other observers. The different forms of white cells also vary greatly in the proportions of their occurrence. Ehrlich's figures for healthy adults are as follows:

Lymphocytes	22–25 per cent.
Large mononuclear and transitional leucocytes	2– 4 "
Polynuclear neutrophile leucocytes	70–72 "
Eosinophile cells	2– 4 "
Mast-cells	0.5– 2 "

Pathological Leucocytoses.—Pathological leucocytoses occur after hemorrhage, as the result of cachexias, as an ante-mortem condition in various diseases, and as the result of inflammations. From a practical point of view in surgical diagnosis, inflammatory leucocytosis is the most important variety, and it is to be borne in mind that in this condition the polynuclear forms are those chiefly concerned in the increase.

The practical diagnostic value of the leucocyte count in pyogenic infections may be summarized as follows:

1. In the presence of an evidently acute and intense purulent infection, absence of leucocytosis indicates that the system is making but feeble efforts to overcome the infection; a high percentage of polynuclear cells is always present; the prognosis is grave.

2. In the case of abscesses or other localized purulent collections which have existed for some time, absence of leucocytosis indicates that the bacteria are dead, or that the pus is entirely shut off from the general circulation; i. e., encapsulated by granulation or fibrous tissue.

3. The above conditions excepted, pyogenic infections are regularly attended by an increased number of leucocytes in the blood; the increase involves a relative increase of the polynuclear forms.

4. A high degree of leucocytosis indicates an intense process, although the inflammatory focus may be large or small.

5. A steadily increasing number of leucocytes or a relative increase in polynuclear cells indicates that the inflammatory process is increasing in extent or in severity, or both.

6. A sudden marked increase in the leucocyte count indicates often that the purulent infection has invaded new structures—a joint, the peritoneum, the cranial cavity—or that the process is spreading rapidly.

7. Deep-seated foci of suppuration not accessible to ordinary methods of examination—such as lie, for example, in the medulla of the long bones, in the perirenal connective tissue, in the liver, or in the venous sinuses of the cranium—may give rise to leucocytosis before any apparent local signs or symptoms exist. In such instances the leucocyte count may aid greatly to establish a probable diagnosis.

8. A moderate increase of leucocytes is 15,000 per cubic millimeter; a large increase is 30,000; above that number is very high indeed, and indicates an intense infection.

9. After an abscess or other inflammatory focus has been evacuated, the number of leucocytes falls slowly or rapidly until the normal number is reached after a variable time. A subsequent rise often indicates imperfect drainage or pocketing of pus.

10. A number of conditions may arise, either independently or after surgical operations, such that a suspicion may be aroused of the presence of pus. A normal leucocyte count and a low polynuclear count are valuable aids in eliminating a pyogenic infection. Such are typhoid and malarial fevers, many

forms of colic affecting the abdominal organs—the kidney, the biliary passages, the intestine, the uterus—also abdominal neuralgias. (See also section on appendicitis, Chapter XXIX, for further details.)

Pyemia.—Pyemia is that form of pyogenic infection in which disseminated foci of suppuration are produced by the lodgment of infectious emboli in the small arteries and capillaries. The emboli originate in infected thrombi formed in veins, the seat of a thrombophlebitis, caused by the growth in the vein of one or other of the pus-producing microbes. The vein may be infected from without by extension through its walls of an infectious inflammation of the surrounding tissues, or bacteria in the circulating blood may in certain situations become adherent to the wall of the vein, there to grow and multiply. An infected thrombus is thus formed, and may become the source of emboli which lodge in distant parts. When such emboli, bearing actively growing pus microbes, finally lodge in a minute vessel, the area supplied by such vessel becomes anemic, the microbes speedily multiply in its substance, and a focus of suppuration—an abscess—is thereby formed. Any of the pus-producing organisms may cause pyemia. One or other of the pyogenic staphylococci oftener than others, and the Staphylococcus pyogenes aureus very commonly.

1. Pyemia may originate from an infected wound at any time until healing is complete.

2. From any purulent focus in the tissues containing living pus microbes, irrespective of the age of such a focus; i. e., after an infected wound long healed.

3. As the result of subcutaneous injuries, usually of a trifling character, which have produced a place of diminished resistance in a situation favorable to the implantation upon the inner walls of small veins of pus-producing germs circulating in the blood (osteomyelitis).

The disease is characterized by the formation of *abscesses in various situations, by fever of an intermittent type, and by chills.* The chills are usually accompanied by a sudden marked rise of temperature, and are generally a part of the reaction of the system to the lodgment of a new embolus and the formation of a new focus of suppuration. In the course of a few hours the temperature falls to normal or below, and this fall is accompanied by sweating.

Methods of Infection and Varieties of Pyemia.—For purposes of description we may divide cases of pyemia into several groups: Those in which there exists an *infected wound*, old or recent, or an *acute or chronic suppurative process* readily accessible to observation, and those arising from some *hidden focus of pus* not readily recognized on superficial examination, due to a wound already long healed or to an *encapsulated pus focus* containing living microbes suddenly set free in the circulation, or to some acute process originating apparently *de novo*, and so situated that local signs and symptoms are, for a time at least, not distinctive. In those cases following a recent injury, or an

acute inflammatory condition whose signs and symptoms are evident, the diagnosis of pyemia offers no difficulties. In those arising after a wound has long been healed, or from some hidden and unsuspected inflammatory focus, for a time at least the diagnosis may not be clear. To this category belong some cases of acute osteomyelitis of the long bones.

Certain kinds of injuries and diseases are especially liable to the occurrence of pyemia. Compound fractures of the long bones were, in preantiseptic days, very commonly followed by death from this cause; infected wounds of large joints; severe crushing injuries of the extremities, if neglected. Among diseases, carbuncle of the lip and erysipelas of the face are sometimes followed by pyemia due to thrombophlebitis of veins communicating with the sinuses of the cranium; inflammation of the middle ear and mastoid process of the temporal bone due to the close proximity of the sigmoid sinus. Septic infection of the interior of the uterus sometimes has pyemia as a sequel. Suppurative lesions of the intestines—notably appendicitis—are sometimes followed by a thrombophlebitis of the veins of the mesentery; in this manner the infection is carried to the branches of the portal vein in the liver, and a suppurative process is thus inaugurated in the liver substance around the branches of this vein.

The metastatic abscesses of pyemia occur in many situations. The heart and lungs are, of course, the organs through which the emboli must first pass, and abscesses in the heart muscle, or sometimes endocarditis or pericarditis, result. Abscesses in the lungs are common; many of the emboli are small enough to pass through the lung capillaries, enter the general circulation, and lodge in the kidneys, the liver, the spleen, the muscles, bones, joints, lymph glands, the parotid, the brain, or other tissues, to become centers of suppuration.

Clinical Course.—The course of the disease varies a good deal in different cases. In the most acute forms an intense septicemia coexists, and the secondary foci hardly have time to produce symptoms before death occurs—often after eight or ten days or less. Subacute cases run their course in three or four weeks, and chronic cases may last for many months. In the more rapidly fatal cases the secondary foci are often numerous, and situated in the viscera. In those which are less acute the metastatic foci are usually fewer. They may be situated in the viscera, or quite often in the bones, joints, or muscles. The presence of the secondary abscesses may give rise to marked symptoms or to none at all, according to whether they seriously interfere with important functions or not.

An endocarditis, a pleuritis, a nephritis will be recognized by the ordinary signs of these conditions; a brain abscess or a meningitis will produce symptoms more or less characteristic, etc.: headache, delirium, coma, or paralysis of special senses or groups of muscles. Pyemic abscesses in the muscles and in joints, and in fact in all ordinarily accessible regions, usually give rise to a far less intense inflammatory reaction than do ordinary acute processes. They are therefore less painful and less tender, and may only be discovered

by accident, since redness of the skin overlying the abscess is often absent. The presence of swelling and fluctuation in a joint or the formation of a rather diffuse fluctuating or boggy swelling in the muscles of a limb, and perhaps a complaint of slight pain or mere discomfort from the patient, may be all to attract attention to an abscess which may contain a pint of pus.

Symptoms.—The symptoms, *constitutional* and *local*, of pyemia vary a good deal according to the degree of accompanying septicemia, the acute or chronic course which the disease may assume, and the situation of the metastatic foci. If pyemia begins while the individual is suffering from an infected wound or acute septic inflammation, the occurrence of a chill and a sudden rise of temperature to 104° to 106° F., followed by as rapid a fall, nearly or to the normal, and profuse sweating, will at once lead to the suspicion of an embolic metastasis. The pulse undergoes a corresponding elevation along with the temperature, but remains rather rapid after the temperature has declined. The occurrence of subsequent chills and abrupt elevations of temperature is usually quite irregular; these may succeed one another several times in twenty-four hours, or every day, or every two or three days, or there may be intermissions of a number of days; during these intermissions there may be moderate fever of a continuous or remittent type, or none at all. When the chills, fever, and sweats occur regularly, the general signs and symptoms may closely resemble malarial fever. The pulse remains rapid even during these intermissions.

Throughout the disease there is loss of appetite, a coated tongue, often a foul breath—sometimes the odor of the breath is cadaveric in character, sometimes of a sweetish, sickening quality; nausea and vomiting are not uncommon. As the disease progresses, diarrhea is often developed; the skin becomes tinged with yellow—this jaundice is usually of a hematogenous origin, less often it is due to a catarrhal inflammation of the intestine, causing obstruction at the mouth of the common bile duct, sometimes to metastatic abscesses in the liver. The spleen is enlarged and often palpable. The mind usually remains clear unless septicemia is also present. The patients are restless, often irritable, and annoyed by lights and noises. They are anxious and depressed; they sleep but little. After each chill and rise of temperature with the formation of a new metastasis the condition of the patient is distinctly worse. Emaciation is progressive; food is swallowed, but not assimilated; profound anemia is developed. The blood changes are: a rapid diminution of the number of red cells and hemoglobin, with more or less marked leucocytosis of a character similar to that which occurs in other suppurative processes. Petechial hemorrhages into the skin are not uncommon.

The condition of the original wound undergoes a marked change when pyemia occurs. If active suppuration has been going on, the wound discharge diminishes. The surface of the wound becomes pale, dry, and shiny. Existing granulations become anemic and flabby, or melt away, leaving the wound surface covered by a grayish, necrotic pellicle. The suppurative process may, on

the other hand, advance in an insidious manner without much external evidence of its progress. The subcutaneous tissues, the muscles, and the joints, and the intermuscular planes of a limb, may thus be rapidly but insidiously invaded, and new abscesses may thus appear from day to day until the whole limb is riddled. The blood-vessels may undergo ulceration, and dangerous or fatal bleeding may occur.

The occurrence of each new chill should lead to a careful examination for the detection of a new abscess, for such may be found accessible to surgical treatment. If the disease is fatal, prostration becomes extreme, and death occurs from exhaustion. Unconsciousness may supervene a day or two before the fatal issue. Acute cases of pyemia are almost uniformly fatal. A few subacute cases and chronic cases recover if the purulent collections are few and accessible, so that they can be removed or evacuated. Metastatic foci in the liver, lungs, spleen, brain, or kidney are more dangerous than those in the muscles and subcutaneous tissues. The intensity of the accompanying septicemia has an important bearing on the prognosis.

In those cases following chronic suppurative lesions—such as chronic otitis media, chronic osteomyelitis with sinuses, chronic superficial ulcerations—the history and the presence of a chronic focus of suppuration will greatly aid in establishing the diagnosis. In certain situations it may be possible to recognize inflamed and thrombotic veins as hard, tender cords proceeding from the origin of the infection toward the heart. Sometimes the venous thrombosis may give rise to definite signs by interference with the circulation of the part. Thus, in acute osteomyelitis, thrombosis of the deeper veins causes swelling of the limb and dilatation of the superficial veins of the affected extremity. Thrombosis of the cavernous sinus causes bulging of the eyeball and swelling and edema of the eyelids and conjunctiva.

The so-called cases of cryptogenic pyemia—i. e., cases in which the original focus of infection is hidden or insignificant—present certain difficulties in diagnosis. A careful examination should be made of the nose, mouth, throat, ears, urethra, bladder and prostate, anus and rectum, the cutaneous surface, the lymph glands of the neck, axillæ, and groins. The joints should be carefully inspected, and palpated for signs of inflammation. Points of tenderness should be sought along the shafts of the long bones, particularly near the epiphyseal lines.

Certain diseases should be excluded. In malaria leucocytosis is absent. There is often a malarial history, and usually the malarial organisms may be detected in the blood. The spleen may be found notably enlarged in both conditions. The diseases most likely to be confounded with pyemia—notably that form of the disease complicating suppurative inflammation of the middle ear—are typhoid fever and acute miliary tuberculosis.

Malignant endocarditis may closely resemble pyemia with numerous visceral metastases. The presence of endocardial murmurs and the absence of signs of metastasis may be the only means of differentiation.

Differential Diagnosis.—Hessler has prepared a table intended to differentiate these conditions. To this table must, of course, be added leucocytosis, or at least a high polynuclear count in pyemia. It is here quoted:

Symptoms.	Otogenic Pyemia.	Typhoid Fever.	Acute Miliary and Meningeal Tuberculosis.
Beginning:	Sudden, with severe head symptoms — dizziness, vomiting, headache.	Begins with progressive prodromal symptoms, disorders of the general condition, only rarely (Liebermeister) with a chill and elevation of temperature to 40° C.	Sudden aggravation of an old bronchial catarrh, with dull headache and depression.
Running from the ear:	Has always preceded.	Accidental complication, occurs for the first time in the fourth or fifth week.	A complication of lung tuberculosis.
Chills:	Frequently recurring after variable intervals, followed by sweats.	Rare.	Often at beginning a single chill, shiverings frequent in course of the disease.
Temperature:	Highly variable, atypical, going above 41° C.; often subnormal.	According to Wunderlich intermittent, slowly rising and falling. Absence of temperature elevation rare.	At the beginning continuous at a moderate elevation, later hectic, at last subnormal, often like that of typhoid.
Sensorium:	For the most part not influenced in typical cases; disturbances as a result of headache, alternating with or following delirium.	Is increasingly disturbed at the end of the first week; later, muttering combined with delirium. Picking at the bedclothes.	Only slight delirium; later sopor and coma.
Headache:	Severe, one-sided, variable near the ear and occiput. Increases with pressure on the neck (MacEwen).	Equally distributed over the head, without changing.	Dull, variable, equal on both sides.
Vomiting:	Frequent, often recurring with the other signs of brain irritation.	Rare.	Frequent, especially in meningeal tuberculosis.
Delirium:	Frequent, varying with other brain symptoms, increasing in children to convulsions.	More bland.	Especially in meningeal tuberculosis.
Lung symptoms:	Rapidly transitory, scarcely to be demonstrated, varying between bronchitis, metastatic abscesses with pleurisy, and pyopneumothorax.	Usually bilateral, bronchitic, in posterior lower portions.	Breathing disproportionately rapid, increased to orthopnea. Sounds normal or only large râles.
Metastases:	Especially frequent in the lungs, rare in the liver, in all organs of the body.	Not present.	Not present.
Appetite:	Good at first, then absent.	Slight.	Slight.
Tongue:	In mild cases not coated.	Dry, coated, protruded with tremor.	Usually remains moist.

Symptoms.	Otogenic Pyemia.	Typhoid Fever.	Acute Miliary and Meningeal Tuberculosis.
Pulse:	Hard, full, increased frequency in chills and fever; disproportionately high in sepsis.	Hard and full, later soft, dicrotic, 80–100, parallel with temperature.	Disproportionately high; 120–150, soft and small.
Course:	Irregular in the intensity of the phenomena and in duration.	Characteristic temperature curve over period of three to four weeks.	Irregular, lasting two to three weeks.
Abdomen:	Rare distention, occurring after the second week.	Frequently distended in the second week.	Not especially distended.
Roseola:	Lacking; but we find elevated red flecks not disappearing on pressure.	Characteristic roseola in second week, especially in the lower breast and abdominal region, not sensitive on pressure, often elevated.	Lacking.
Diarrhea:	In severe cases, toward the end, then watery, profuse, fetid.	Characteristic pea-soup stools.	Only in simultaneous intestinal tuberculosis.
Abdominal pain:	Frequent over lower spleen when metastases are present.	Ileocecal pain in the second week.	Usually lacking.
Spleen:	Almost without exception enlarged and palpable.	Constantly swollen and palpable.	As a rule, moderately swollen.
Icterus:	Frequent, in mild cases not with certainty.	Rare.	Rare.
Death:	In coma, usually by embolism of lungs.	In coma, with heart-failure.	In coma, or collapse with failure of lungs or brain.
Optic neuritis:	Often very clearly present, rarely septic retinal hemorrhage.	Not present.	Not present, choroidal tubercles frequently demonstrable.
Blood examination:	Gives, when positive, different kinds of microorganisms (streptococci and staphylococci).	Only typhoid bacillus.	Frequently tubercle bacilli.

CHAPTER III

SPECIAL DISEASES OF WOUNDS

ERYSIPELAS

Erysipelas is an acute inflammation of the skin and subcutaneous tissues and of the mucous membranes, characterized by a sudden onset, a tendency to spread slowly or rapidly along the surface, rarely into the deeper tissues, and a self-limited course of variable duration, usually with complete *restitutio ad integrum* of the affected tissues. Suppuration is infrequent. The disease is usually attended by marked constitutional symptoms, including fever. Erysipelas is *caused* by the inoculation of a wound or abrasion of the skin or mucous membrane with the Streptococcus erysipelatis, probably identical with, or a variety of, the Streptococcus pyogenes, and possessing the same gross and microscopic appearances as well as identical behavior in nutrient media. The cocci occur in chains, single pairs of cocci forming the links of the chain. Single cocci are from 0.3 to 0.4 μ in diameter. The Streptococcus pyogenes may be stained with any of the anilin colors and by Gram's method. If inoculated into the ear of a rabbit, a local erysipelatous process is produced. The cocci can be demonstrated in the lymph spaces and lymph canals of the affected tissues, in the protoplasm of the tissue cells, and in the blood capillaries as well as in the contents of the vesicles which form upon the skin surface. The germs are most abundant in the advancing border of the inflammation; they are usually absent from the tissues where the process has existed for several days, but are found in the healthy-looking skin beyond the advancing border. The inoculation of the disease may take place in a wound, clean or infected, during any stage of the healing process, or in ulcers of any description. The period of incubation is short—twelve to forty-eight hours.

Onset of the Disease.—In some cases the local lesion and the constitutional symptoms appear together. In others the disease begins with prodromata, often with a chill and a rapid rise of temperature to 103°–105° F. There is disturbance of the stomach, sometimes vomiting, and pain in the epigastrium; the tongue is coated; headache and prostration are common. A leucocytosis of from 12,000 to 20,000 is commonly present during severe cases of erysipelas. In mild cases the leucocyte count is usually lower—7,000–8,000 (Hayem). Relative increase in the polymorphonuclear forms is the rule. When suppuration occurs the leucocytes may suddenly rise in number to a high grade—

39,600 (Reinert), 59,400 (Epstein). Leucocytosis generally varies directly with the fever, but may be entirely absent even when the fever is high. Bacterial examinations of the blood have generally been negative, but a few positive results have been obtained in severe cases of erysipelas—notably of the phlegmonous type.

The *local lesion* follows infection in twelve to forty-eight hours. Near the site of the inoculation the skin becomes bright red in color, at first in spots; the spots soon coalesce, and a uniform red area is produced which slowly or rapidly increases in size. The inflamed skin is swollen, a little elevated, edematous, hot, and moderately tender. The subjective symptoms of burning and itching are present. Pain is usually not marked. The red border advances in an irregular, wavy line, having a contour which has been likened to the advancement of the fire in a piece of burning paper. The redness is commonly of a bright, vivid quality, in some cases tinged with yellow, in others the redness may become dusky, almost purple. Vesicles form upon the surface containing clear serum; later the serum becomes cloudy, and the vesicles dry up, forming crusts. In some cases the vesicles coalesce into large blebs (erysipelas bullosum). In facial erysipelas, swelling of the eyelids, ears, and lips is often very great. The disease progresses along the surface in a very irregular manner—sometimes fast, sometimes slow—the redness fades in one part while advancing in another. A new focus of inflammation may suddenly appear in a distant part of the body. The disease rarely lasts longer than fourteen days, but relapses are common, and a part from which the disease has disappeared may be reinfected. Desquamation regularly follows. (For a description of erysipelas of the mucous membranes, see Erysipelas of the Face.)

Constitutional Symptoms.—The gravity of the constitutional symptoms corresponds usually with the extent and severity of the local lesion. The more severe constitutional symptoms often occur in erysipelas of the face and head. They are often grave, notably in those debilitated by bad hygienic conditions and by drink. The fever is often high; the temperature is continuous, remittent, or intermittent, or quite irregular. Severe headache is usual in cases of facial erysipelas, and delirium, sometimes of a furious character, occurs, notably in chronic alcoholics. Unfavorable symptoms are vomiting and diarrhea—sometimes of a bloody character—delirium, stupor, and coma. Fading of the eruption is usually followed by immediate subsidence of the fever.

A *wound* infected with erysipelas may undergo little or no change in appearance. Primary union, even, may not be interfered with. A granulating wound may be unchanged or the granulations may become pale and flabby, or become covered with a diphtheritic membrane. Only in bad forms of erysipelas—notably in the cases of phlegmonous and gangrenous erysipelas—do the wound edges become necrotic. Swelling and tenderness of the communicating lymphatic glands are regularly present, often very early in the disease. Occasionally the inflammation of the glands may be followed by purulent softening and abscess.

Complications of Erysipelas.—The complications are numerous and varied. Localized subcutaneous abscesses may occur; they are often characterized by rather a subacute course. There will be formed one or many subcutaneous swellings, without redness of the overlying skin. Moderate pain and tenderness with distinct signs of fluctuation will be noted. Diffuse and progressive necrosis and purulent softening of the subcutaneous tissues may occur, accompanied sometimes by widespread sloughing, and even by putrid decomposition of the subcutaneous tissues, and of the loose connective tissue of the intermuscular planes, and even of the skin itself (Erysipelas phlegmonosum, Erysipelas gangrenosum). In these cases there will be profound constitutional depression and marked local swelling, but redness of the skin may be absent until the skin is about to be perforated. If the process involves the skin at the start a hard and brawny swelling will be produced; the skin will be red, or dark red, or even purple in color. During the earlier stages of the process, while the inflamed skin or subcutaneous tissues are undergoing necrosis, there may be no pus at all, and the signs of fluctuation will be absent. If an incision be made into the part at this time, a hard edema of the skin and subcutaneous tissues will be noted. The smaller blood-vessels will bleed but little, or not at all, and the necrotic tissues will resemble bacon—both in appearance and consistency. If incised at a later period, after purulent softening has occurred, the subcutaneous tissues appear as yellowish, sloughing, spongy masses, sometimes having a putrid odor, from which a thin and watery pus exudes. Additional infection with gasogenic bacteria produces swelling and the characteristic crackling of the tissues upon pressure, as well as transmitting a sensation of crepitation to the fingers.

The complications affecting the contents of the skull are sinus phlebitis, meningitis, and pyemia (see Head). Pyemia is to be recognized by the characteristic chills, followed by a rapid rise of temperature, as sudden a decline to normal or below, followed by sweating and by the formation of pyemic abscesses (see Pyemia). Pleurisy and pneumonia occur, and are to be recognized by their physical signs. Pericarditis and endocarditis are occasional complications. Acute nephritis is not uncommon, to be recognized by the characteristic changes in the urine, a diminished quantity of urine, and the presence of albumin, casts, and blood cells. Peripheral neuritis and neuralgias may be sequelæ of erysipelas.

TETANUS

Tetanus is a disease caused by the inoculation of a wound with tetanus bacilli. The tetanus bacillus is a rod-shaped germ 4 to 5 μ in length, with rounded ends. The bacillus forms spores. An enlargement occurs at one end of the rod, forming a rounded knob, giving the organism somewhat of a battledore shape. The enlarged end is three or four times the diameter of the rod itself. The rods may be found singly or in threads. The bacilli possess motil-

ity, and cilia may be demonstrated by proper staining. The cilia may occur at the ends of the rods or from various points. The tetanus bacillus is anaërobic, and cannot be cultivated in the presence of oxygen upon ordinary plate cultures. In order to determine the presence of the bacilli in a suspected case of tetanus the discharge from the wound may be stained with gentian violet, methylene blue, or other anilin stain. A recognition of the spore-producing battledore forms is necessary for a microscopical diagnosis; if this fails, deep cultures may be made in glucose gelatin for thirty hours at the body temperature, and the culture examined for spore-bearing bacilli. Inoculation experiments upon mice and guinea pigs may also be tried. (H. C. Ernst, *loc. cit.*)

The germ is found in the tissues at or near the site of inoculation, but it has not been demonstrated in the blood or in distant organs, except in very rare instances. It is supposed that the symptoms of the disease are caused chiefly by the absorption of the poisonous products accompanying the growth of the bacilli at or near the point of inoculation. The poison seems to exert its influence chiefly upon the central nervous system, and through the medium of the peripheral nerves upon the muscles. There are no characteristic lesions of tetanus found after death. Punctate hemorrhages have been found in the brain of men and animals after death from tetanus, and changes have been described in the medulla and in the cord, as well as in the peripheral nerves, but they do not appear to be constant.

Tetanus follows punctured wounds and contused and lacerated wounds of the deeper tissues, rather than superficial wounds, as might be expected from the anaërobic habits of the organism, but superficial abrasions are not exempt from infection, a mere scratch of the forearm having been followed by tetanus in one of my own cases, as well as in other cases reported. The natural *habitat* of the tetanus germ is the soil; certain localities appear to be favorable for its occurrence—for example, the soil of certain streets in the city of New York has been found to contain numerous tetanus germs from time to time, and certain districts on Long Island are said to furnish an unusual number of cases of tetanus. In tropical countries the disease appears to be more common, and of a more severe type. Wounds of the hands and feet appear to be inoculated with tetanus more often than wounds in other regions. Such wounds are more apt to be contaminated with the soil, and it is probable that the inoculation may often occur from the contaminated skin in a certain proportion of cases rather than from the instrument creating the wound. Wounds of the hand produced by the wadding from toy pistols have been followed in the city of New York by tetanus in quite a large number of cases. Following the celebration of the Fourth of July in this city, a considerable number of cases annually occur from wounds of this character upon the hands of boys. Putrid organic materials and the feces of the herbivorous animals often contain the germs of tetanus.

Acute and Chronic Types of the Disease.—Tetanus is usually described as occurring in an acute and a chronic form, but no definite line can be drawn

between the two types of the disease. (In two acute cases of tetanus, Cabot reports a leucocytosis of 11,900 and 19,600, respectively—Ewing.) It has been noted that a large proportion of those cases of tetanus which develop within a week or ten days from the time of inoculation run a severe and usually rapid course, and end in death in a large proportion of cases. In those cases developing later than fourteen days from the time of inoculation the type of the disease is less severe, and a large proportion of them recover independently of the character of the treatment.

Invasion of the Disease.—The first symptoms of an attack of acute tetanus are usually stiffness of the muscles of the lower jaw and of the neck, sometimes difficulty in swallowing, sometimes stiffness of the muscles of the wounded limb. The contraction of the masseter muscles is usually marked, and within a few hours the mouth can only be opened with difficulty, if at all. Painful spasmodic contractions of these muscles are soon added. During the next twenty-four hours the muscles of the back of the neck become contracted and rigid, and later all the muscles of the back. The muscles of the front of the abdomen and of the lower extremities are next affected. The muscles of the upper extremities are usually but slightly involved. The contractions of the muscles are tonic in character, and to the touch they feel of a boardlike hardness. When the disease is fully developed there are added clonic spasms, of greater or less severity, brought on by slight sources of external irritation. Marked opisthotonos may occur during these attacks.

Course of the Disease.—After twenty-four hours the disease is usually fully developed. The temperature, which was normal or but little elevated at the onset, rises several degrees. The patient suffers from retention of urine. There is generally from time to time profuse sweating, notably after the occurrence of a general convulsion. Attempts at swallowing cause a marked spasm of the muscles of deglutition and pain. The contracted muscles everywhere are painful, and the pain is greatly increased by the clonic spasms. The mind usually remains clear throughout the disease, although confusion of ideas and even delirium are not uncommon in severe cases either as the result of the disease or of the drugs administered. The patient is unable to sleep; he lies in bed, sometimes upon his back, sometimes upon his side. The contraction of the muscles of the face produces a distorted expression of the countenance. The eyelids are puckered and the eyes partly closed. The nostrils are rather widely opened. The lips may be drawn away from the teeth, producing the appearance known as the sardonic grin. The head is drawn strongly backward; there is a deep hollow in the lumbar region of the back; the lower limbs are rigidly extended; there is plantar flexion of the feet. In the most acute cases of tetanus the temperature may be very high. The temperature is usually continuous, sometimes with moderate remissions.

A fatal result may occur in forty-eight hours or less. Patients who survive the first six days of the disease have a better chance of recovery. Death occurs from exhaustion, due to the prolonged and violent muscular contractions, to the

inability to swallow food, to pain, to loss of sleep, and occasionally to respiratory failure during a general clonic convulsion. If the patient is to survive, the fever diminishes; the clonic muscular spasms become less marked, and cease; the tonic contractions slowly diminish in intensity; sleep becomes possible; the patient is able to swallow. The muscular rigidity ceases in the extremities, and later in the muscles of the back and trunk. Convalescence is usually gradual, and the contraction of the muscles affecting the jaws may exist for several weeks. Relapses are not uncommon. Severe general convulsions and high fever are of bad prognostic import.

Subacute and Chronic Tetanus.—The subacute and chronic cases of tetanus are usually developed after a longer period of incubation—from ten to fifteen days, or even more. The symptoms are like in kind to those of acute tetanus, but less severe. In these cases the wound may be already healed, or it may be partly healed and have the appearance of a mild infection. If healed, the scar may be somewhat red, swollen, and sensitive on pressure. There may be moderate fever or, in the chronic cases, none at all. The contraction of the muscles may be general, or confined to certain groups of muscles. The muscles of the jaw are uniformly contracted. The muscles of the extremities may escape, and the spasms may be confined to the jaw, some of the muscles of the back, and to the muscles of the affected limb. Some of the cases of subacute tetanus, even those which do not develop for a fortnight or more, are nevertheless severe in character and fatal in their results.

Head Tetanus (Tetanus hydrophobicus).—This form of the disease follows wounds inoculated with tetanus germs in the region supplied by the twelve pairs of cranial nerves. It is characterized commonly by unilateral paralysis of the muscles supplied by the facial nerve, and by notable spasm of the muscles of deglutition. Ptosis is usually marked. The patient is unable to swallow, and attempts at swallowing are followed by spasmodic contractions of the muscles of the throat (Tetanus hydrophobicus). The mortality is said not to be greater than in cases of ordinary tetanus.

Differential Diagnosis.—The differential diagnosis between tetanus and other conditions should not be difficult. From poisoning by strychnin it is to be distinguished by the fact that, though the muscular contractions in strychnin poisoning are tetanic in character, complete relaxation of the muscles occurs between the spasms; nor are the muscles of the jaw especially affected in strychnin poisoning more than others. Lockjaw is absent. In strychnin poisoning there is photophobia, and objects are seen of a green color. The inflammatory conditions of the mouth, neck, and throat, which lead to inability to open the mouth, are usually accompanied by a definite local lesion not difficult to recognize, and the hard, boardlike condition of the masseter muscles is absent. Inflammation of the temporal maxillary articulation is attended by local pain and tenderness. The condition known as tetany bears a similarity to tetanus only in name. This disease sometimes follows operations upon the thyroid gland (see also Gastric Tetany). A nonfatal condition of muscular

contractions somewhat similar to tetany may occur in young hysterical and nervous individuals. The symptoms are tonic spasms of the muscles of the upper extremity, rarely the lower. Pressure upon the nerve trunk supplying the affected muscles produces spasm of these muscles (Trousseau's symptom). (See Gastric Tetany.)

RABIES

Synonyms.—Hydrophobia, madness; French, La Rage; German, Hundswuth, Wuthkrankheit; Italian, Rabbia, Lyssa.

Definition.—Rabies is an acute, contagious disease, produced by inoculation of a wound with a specific virus contained in the saliva of a rabid animal, usually transmitted by a bite.

The exact nature of the infectious agent is not certainly known, but that it is some form of micro-organism there can be no doubt.

Rabies in Man.—In man the disease is characterized by a rather long period of incubation, by extreme mental depression and anxiety, by the occurrence of violent spasms of the muscles of deglutition and respiration, later by general convulsions, delirium, and finally by paralysis, exhaustion, and death. All cases end fatally, and the duration of the disease is but a few days. Reported recoveries are few and doubtful.

Animals Affected.—All mammals and birds are susceptible. The disease is frequent among dogs, and the dog family in general, is less common among cats, and is occasionally observed among cattle, sheep, and pigs, rarely in horses.

Distribution.—Rabies occurs in all civilized parts of the world except in Australia, where it has been kept out by strict quarantine. Of the countries of Continental Europe, it is very frequent in Russia; has become rare in Germany, Norway, Sweden, Denmark, and Switzerland. It is rare in England, and is fairly common in the United States. In those countries where the disease is now infrequent it has been held in check by strictly enforcing the muzzling of dogs. Hydrophobia from the bites of animals other than the dog is relatively rare in all countries, though a moderate number of cases occur in Russia from the bites of rabid wolves. The danger of bites from rabid animals varies with the extent and situation of the wounds and with the species of animal. Severe lacerated wounds and wounds of regions richly supplied with nerves—the face and hands—are more dangerous than wounds of the lower limbs and trunk. This is partly owing to the protection afforded by clothing, since much of the virus contained in the saliva remains on the cloth, the teeth being rendered comparatively clean. Bites involving large nerve trunks anywhere in the body are particularly dangerous. It has also been observed that dogs and other animals with long thick hair are less apt to be infected than are animals with short hair, or those from whom the hair has been cut away. While the largest number of cases follow bites by dogs,

bites by wolves and cats are more dangerous. While deep wounds are more apt to be followed by the disease, still inoculation may occur upon abraded surfaces, as from licking by a pet animal, and the disease has followed inoculation while performing autopsies upon the bodies of men and animals dead of the disease. Men are more likely to contract hydrophobia than women, partly owing to their mode of life and partly to the protection afforded by skirts and petticoats. Two fifths of all cases of hydrophobia occur in children less than fifteen years of age, and many of the bites are upon the head, neck, and face. This is owing to their use of the streets as a playground, to their ignorance of danger, and to their weakness and consequent inability to fight off a rabid dog. What proportion of bites by rabid animals are followed by hydrophobia it is not easy to say; probably less than half. The statistics given vary from 16.6 per cent by Leblanc to more than fifty per cent (Bouley). Among 266 persons bitten, collected and reported by Bouley, there were 152 deaths. Of these, 120 were bitten on the face and hands. The mortality following the bites of rabid wolves has been estimated at from sixty to eighty per cent. More cases of hydrophobia occur in the spring and summer months than during the rest of the year.

Nature and Distribution of the Contagion.—From its behavior we know that rabies must be due to some specific organism, but as yet no one has been able to recognize or isolate it with certainty. The disease bears a striking analogy to tetanus, since in its distribution the virus follows the peripheral nerves to the central nervous system. The virus is found in all parts of the nervous system after death, but is most abundant and produces the most marked microscopic changes in the medulla. The passage of the virus from the point of inoculation to the medulla may be prevented by severing the spinal cord, as proven by experiment. The saliva and the salivary glands contain the virus, and in the saliva the virus is present for a day or two before the symptoms of the disease are manifest. The pancreas and suprarenal capsule may contain the virus, as may also the milk. The blood, the muscles, and the lymphatic glands are innocuous. The virus, when filtered through plaster and injected into animals, produces a toxemia with nervous symptoms resembling the disease itself. The virus is destroyed by light, by drying, and by heat. Direct sunlight destroys it in about forty hours. Water preserves it, and in glycerin it may be kept almost indefinitely. When dried in the air, protected from light and putrefaction, it gradually loses its virulence, and at the end of fifteen days becomes harmless, this being the method, now in general use, used by Pasteur in preparing his material for protective inoculation. The virus is not injured by cold, and may remain active in the bodies of animals buried in the ground for many days. It is quickly destroyed by 1–1,000 $HgCl_2$ solution, and by formalin. It loses its virulence almost immediately when mixed with an equal quantity of bile.

Incubation.—The period of incubation in man varies within wide limits. The shortest period has been twelve days. The longest is not definitely known.

It is certainly as much as a year, and may be longer. The average is forty days. It is unusual for the disease to develop after three months, and rare after six months.

Pathology.—There are no gross pathological changes characteristic of rabies found after death in either men or animals. In man the blood remains fluid after death, and is dark in color. Congestion of the throat, gullet, and stomach are common. There may be congestion of the lungs, with emphysema. The brain and its meninges are often congested. In dogs similar lesions are observed, but the most characteristic finding, and one which furnishes strong corroborative evidence in a suspicious case, is the absence in the stomach of food and the presence of foreign material—wood, straw, grass, hair, wool, and the like. Such are found in ninety per cent of the cases.

Postmortem Diagnosis.—The most valuable means of diagnosis is by the microscopic examination of portions of the nervous system. When a human being has been bitten by an animal suspected of rabies it is important to know whether the animal was actually rabid in order that preventive treatment may be commenced at once. Formerly the only certain means of diagnosis was by inoculating an animal, usually a rabbit, with some of the medulla of the dog supposed to have been mad. The inoculations were made beneath the dura of the rabbit in order to produce the most active infection and the shortest period of incubation, but this period, being from sixteen to twenty days or more, was too long to be useful, since it has been found by experience that in order to procure adequate protection the preventive inoculations must be made within one week of the receipt of the bite. At the present time microscopic examination of portions of the nervous system of an animal dead of rabies furnishes data which are conclusive, so that a positive diagnosis is now possible within from twenty-four to seventy-two hours. The animal should be allowed to die of the disease, since if killed the microscopical appearances sought for may be absent.

The work of Van Gehuchten, Nélis, and Negri have rendered a microscopic diagnosis possible. The details of the two methods given below are from Ravenel, in Osler's "Modern Medicine," vol. iii, page 57 *et seq.*:

Van Gehuchten and Nélis believe that the virus acts by preference on the peripheral cerebrospinal and sympathetic ganglia. The most constant and marked lesions are found in the intervertebral and the pneumogastric ganglia. They consist of the atrophy, the invasion, and the destruction of the nerve cells by new-formed cells, due to the proliferation of the cells of the endothelial capsule. The new-formed cells increase in number, invade the protoplasm of the nerve cell, and finally occupy the entire capsule, the nerve cell proper having completely disappeared, while in its place is seen a mass of round cells. The nerve cells which are not destroyed may show various degenerative changes of the protoplasm and nuclei, such as vacuolation, eccentricity of the nuclei, chromatolysis, etc. In advanced cases practically all the nerve cells may be destroyed, and the section has much the appearance of an alveolar sarcoma. These changes have been found

in a great variety of animals. They are best observed in dogs and cows, but are quite characteristic in all animals studied.

In 1903, Negri announced the discovery of certain bodies in the nerve cells of rabid animals. They are found especially in the horn of Ammon. They are from 1 to 23 μ in diameter, oval, round or triangular in shape, according to their size and position in the cell. They are strongly eosinophilic.

The Negri bodies are described as consisting of a fundamental substance, which is homogeneous, nongranular, and hyaline in appearance, resembling coagulated albumin. Within them are clear shining areas, which at first sight appear to be vacuoles, but under higher powers show one or more points of deeper color. They are quite resistant to external agencies, remaining unchanged for a long time by putrefaction, desiccation (one hundred and eighty-three days), etc. Material may be preserved in glycerin for eighty days without altering the Negri bodies. They are destroyed by thirty-three per cent solution of caustic potash.

They are well brought out by dilute solutions of acetic acid or by ten per cent osmic acid, or by immersion in thirty-three per cent alcohol for forty-eight hours, or by staining after the method of Mann or Romanowsky. They are especially numerous and large in cases of rabies of long incubation period (Negri). They are best developed in the horn of Ammon, less in the cells of Purkinje, and less still in the spinal ganglia and vagus.

The nature of the bodies is unknown. Negri believes them to be protozoa, and considers them the causative agents of the disease. Valentie reports that the virus of rabies is neutralized in the test-tubes as well as the living body by quinine, while no other alkaloid was found which had this power. This is held as strong evidence of the protozoan nature of the bodies.

Babes has made an exhaustive study of the matter and confirms the practically constant presence of Negri bodies in the brain in rabies, although he does not consider them the actual parasite, but rather evidence of the resistance on the part of the cell, by which it is able to englobe and encapsulate the invading organism. He believes the fine round granules coloring a blue or black with the Cajal-Giemsa stain to be the parasite in its active state. These granules are found exclusively in the protoplasm of the degenerated nerve cells in the most severely involved areas of the nervous system, whereas the Negri bodies occur in cells but little altered and having no close connection with the symptoms. He believes the Negri bodies to be encapsulated parasites undergoing involution or degeneration.

For diagnosis by the method of Van Gehuchten and Nélis, the plexiform ganglion of the pneumogastric nerve is selected, as it is easily dissected out, and presents the characteristic changes in the ganglion cells. In dogs, the ganglion is readily found by cutting down on the pneumogastric nerve in the neck, and following it up. Near the skull it divides into two branches, on one of which (the smaller) is found a small, oval, reddish ganglion, the cervical. The larger branch enters the plexiform ganglion, which is easily recognized by its fusiform shape and white or grayish color. It is seldom more than a half inch from the foramen, and it is generally necessary to cut the nerve as it emerges from the skull. The ganglion may be prepared for section by any of the rapid methods.

The best stain for general use is hemalum (Gruber), made up with a 0.5 per cent solution of carbolic acid, and counter stained with eosin. This method has

been in use at the laboratory of the State Live Stock Sanitary Board of Pennsylvania for five years, and has been found most satisfactory. A large number of cases have been controlled by inoculation, and no error has yet been found. While the lesions cannot be considered specific, since similar changes have been noted occasionally in other toxic conditions, and in the ganglia of aged dogs, yet by their extent and constant occurrence in rabies they have an unquestionable significance, and, taken in connection with even a meager history, have an absolute diagnostic value.

Certain precautions must be observed: The animal must be allowed to die of the disease. The lesions may be slight or entirely wanting in animals killed prematurely, and in such cases their absence does not preclude the existence of rabies. If absent after death from the disease, we can positively deny the existence of rabies.

A diagnosis can be made within twenty-four hours by rapid fixation and mounting, and is easily made within forty-eight hours.

The diagnosis by the method of Negri has advantages over the above in that the Negri bodies are usually found early in the disease, are not affected by putrefactive changes incident to delay in obtaining the material, and the technic is more simple. In practice a small portion of the brain should be taken from the cortex of the cerebellum, and also from Ammon's horn, as the bodies may be numerous in one area and not in the other. The pieces of tissue may be fixed in Zenker's fluid embedded in paraffin, and stained with eosin and methylene blue. The bodies show red against the blue background of the cell. The stains of Mann and Romanowsky are especially recommended.

The process of hardening and cutting may be dispensed with and the examination for Negri bodies made directly in the fresh tissues by the smear method, which has been found very satisfactory. It has the great advantage of giving practically an immediate diagnosis. It is described by Gorham as follows: The top and occipital portions of the skull are removed, and, without taking out the brain, pieces 3 to 4 mm. in diameter are taken from the cerebral cortex in the region of the crucial sulcus, the cortex of the cerebellum, and the hippocampus major. These are placed on a well-cleaned slide and crushed under a cover-glass until the matter spreads to the edge of the cover, which is then drawn slowly and evenly the length of the slide, leaving a uniform film of brain matter. The slide is then immersed in wood alcohol for one to three minutes and dried in the air. The stain is made by adding 2 drops of a saturated alcoholic solution of rose anilin violet and 16 drops of a one-half saturated aqueous solution of methylene blue to 18 c.c. of distilled water. Flood the slide with this stain and heat gently until steam rises, wash in water and dry. The Negri bodies appear as pink, crimson, or magenta inclusions in the blue nerve cells. The color taken depends on the condition of the material and the proper mixture of the stains. In early cases the bodies are found only in the large cells, while in advanced cases they are found in all kinds of nerve cells.

Volpino's osmic-acid method is rapid and simple. A portion of the horn of Ammon is removed and cut into segments 3 to 4 mm. thick, which are put into test-tubes containing 4 to 5 c.c. of a one-per-cent solution of osmic acid. After five to six hours or longer they are removed and washed in water for half an hour, then put into absolute alcohol for three to four hours. They may then be cut by hand and

mounted in glycerin. It is not necessary to harden the tissue, since a fairly thin section can be readily pressed out on the slide. The preparation is brownish in color, the cells are light coffee-color, the nuclei paler, and the nucleoli strongly colored. The Negri bodies are seen in the cells, and resemble nucleoli. There may be one or several to a cell.

The discovery of Negri has been abundantly confirmed, and while the etiological significance, as well as the nature of the bodies, is still in doubt, they have been shown to be very valuable for the purpose of making a rapid histological diagnosis. Bertarelli states that in more than 1,000 examinations the Negri bodies were never found in animals free from rabies, and, on the other hand, were present in all infected animals, with three exceptions. Poor, at the Health Department Laboratory, New York, has examined material from 17 cases of rabies from natural infection, 16 cases of the inoculation disease, and 22 controls. The Negri bodies were found in all cases of natural infection, and in all of the inoculation cases except one dog which was killed on the first appearance of nervous symptoms. Among the controls one case of experimental tetanus showed a few minute eosinophile bodies in the Purkinje cells of the cerebellum, which, however, could be differentiated from the Negri bodies. He confirms fully the diagnostic value of the method.

Clinical Diagnosis of Rabies in Dogs.—The period of incubation in dogs is said to be shorter, on the average, than in man. Seven days the shortest period. Thirty days as an average, though it may be prolonged to eight months. The disease is ordinarily described as occurring in two types: the *furious* and the *paralytic type*, according to the predominance of one or the other set of symptoms. In some cases the stage of excitement is prolonged for several days, and is followed by a short paralytic stage just before death, while in others the stage of excitement is very short while the paralytic symptoms are marked from the outset. The latter type is fairly common in dogs, and notably so after experimental inoculation. It is said to be the prevalent type in Turkey. It is far less dangerous to man than the furious type, since the muscles of the jaws are paralyzed so that the animal cannot bite.

Symptoms of the Furious Type.—The early symptoms consist of changes in disposition. The animal is restless, uneasy, and excitable. He will obey his master, but not so quickly as in health. The appetite remains good, and may be excessive. A very constant and highly suspicious symptom, which should be the signal for confining the animal and keeping him under close observation, is the disposition to swallow indigestible articles—pieces of wood, straw, dirt, etc. The animal gnaws and tears at woodwork, blankets, rugs, and other similar articles in an unaccustomed manner. Alternate periods of depression and of excitement are observed. The animal seeks solitude, hides in dark corners, and avoids his friends, and again is more demonstrative and affectionate than normal. At this time he may exhibit signs of transient delirium, watching and attacking imaginary objects. The animal is now very dangerous, and may even bite his friends, if startled. Presently spasmodic contraction of the muscles of deglutition comes on. The animal is no longer

able to eat. He may choke, as though a foreign body were in the throat, and the examination of the mouth is, of course, dangerous. The sound of the bark is altered, and ends in a high-pitched howl different from the ordinary voice. The successive yelps are not followed by complete closure of the jaws. There is no fear of water, and the animal continues to drink greedily until swallowing becomes impossible. It is noteworthy that there is never fear of water in dogs.

The animal soon reaches the furious stage. He has hallucinations of sight and hearing, attacks furiously his master or any other person who crosses his path. Unless confined, he may run for long distances—many miles—finally returning home or continuing until he drops from exhaustion. His coat is rough and dirty, his tail between his legs, his mouth partly open, and frothy, tenacious saliva drops from his jaws. He usually runs straight ahead, and does not turn out of his way to bite unless interfered with. The duration of this stage may be only a few hours or may last three or four days. It is followed by the paralytic stage, characterized by progressive weakness of the muscles, emaciation, paralysis of the muscles of swallowing and of the jaw. The mouth hangs open, and cannot be closed. The animal staggers in his gait, and is finally unable to stand. There is gradually increasing dyspnea. There may be general convulsions. Stupor sets in, from which the animal can be aroused only with difficulty. Death occurs from exhaustion and complete paralysis. The duration of the disease is from three to six days, rarely as long as ten. The furious type is the most common form, and occurs in about eighty per cent of the cases.

Paralytic Type.—The paralytic type of the disease is less common, and far less dangerous to man. It commences, as in the other form, by restlessness and excitement, followed by the desire for seclusion, so that the animal hides and avoids observation. The stage of maniacal fury is wanting. The typical symptoms begin with paralysis of groups of muscles, extending to other groups until all the muscles are paralyzed. The muscles first affected are those of the jaw. The mouth hangs open and cannot be closed, swallowing is impossible, the tongue hangs out, and becomes dry and brown. The animal is quite unable to bite, and apparently does not wish to do so. The saliva drools from the mouth as in the other form. The duration of the disease is very short; death occurs in from two to four days, as a rule, of complete paralysis. Forms intermediate between these two are not uncommon.

The Disease in Man.—Premonitory Symptoms.—The wounds from a rabid bite usually heal without more reaction than is common in other similar wounds. In some cases there is marked depression of spirits and anxiety, though this may have no relation to the disease itself; still, it has been observed in children and in adults who did not know that they had been bitten by a rabid animal. Toward the end of the period of incubation there may be pain and tingling, or numbness in the scars, or pain along the course of the principal nerve trunks of the affected limb. The first symptoms of the disease are usually marked mental depression, together with hyperesthesia of the skin and of the special

senses. There are sometimes chilly sensations, or a chill and a rise of temperature amounting to two or three degrees. After a few hours or a day the patient has a sense of constriction in the throat. Swallowing becomes difficult. There is a sense of oppression in the chest. The voice becomes hoarse. Mental irritability, intense anxiety, and suspicion exist. Attacks of maniacal delirium are only noted in the later stages of the disease. There is a moderate rise of temperature—100° to 101° F.—and a rapid pulse. In some cases the temperature will rise no higher, in others there is a progressive increase in the fever until death, so that the temperature may reach 104° or 105° F., or even higher, during the last hours of the disease. The pulse regularly becomes more and more rapid until death. It is at first full, and later on becomes more and more rapid, feeble, and compressible.

Stage of Excitement.—As the hours go by the condition of the patient grows rapidly worse; there is an ever-increasing anxiety, amounting to extreme terror. The face is pale, and horror is depicted on every lineament. There is extreme thirst. The patient makes desperate efforts to drink water, but the attempts to swallow cause a spasm of the muscles of the throat. The water is ejected from the mouth with some force. These futile efforts lead to a dread of water, until the mere attempt to take it, or even the sight of water will produce spasms of the muscles of deglutition and respiration, with a sense of suffocation, cessation of respiration, and intense agony of mind. These spasms produced by slight external sources of irritation are the most constant and characteristic feature of the disease. Owing to the intense hyperesthesia of the skin and of all the special senses, the convulsive attacks may be brought on by a bright light, by a sudden noise, by a draught of air, or by an odor. The spasms, at first confined to certain groups of muscles, become general. They are tetanic in character. There may be opisthotonos, with suspension of respiration. In some cases they resemble the convulsions of hysteria. During the convulsions the voice is changed in character, and may acquire a quality which has been likened to the bark of a dog. Between the convulsive attacks the muscles are relaxed, thus differing from tetanus, but as time goes on the seizures are more frequent and more prolonged. The patient through terror and agony becomes delirious during the attacks. In the intervals he can usually be recalled to his senses. While maniacal he may do himself or others serious injury, and may strive to bite those about him. There is marked salivation and, since the patient cannot swallow, the viscid saliva drools from the mouth. He is continually spitting in his efforts to get rid of it. Vomiting is frequent. The vomited matter may contain blood. During the attacks there is intense dyspnea, due to the spasm of the diaphragm and intercostal muscles, though the glottis is not closed. Death may occur during one of the prolonged spasms from asphyxia. The duration of the stage of excitement is from one and a half to three days.

Paralytic Stage.—A short time before death the convulsive attacks and the delirium subside. The patient sinks into a state of profound exhaustion,

from which he does not rally. Consciousness may be preserved to the last, or may be preceded by coma. There is complete paralysis. The duration of this stage is usually only a few hours.

Paralytic Type of Rabies in Man.—It is said that the furious type of rabies more commonly follows bites about the head and hands. Following extensive bites, notably those involving much laceration of tissue in the extremities, a form of the disease occurs in which the excitement, delirium, and muscular spasms are entirely wanting. The disease runs the course of an acute ascending spinal paralysis. The first symptoms may be paralysis of the lower extremities. In other cases this may be preceded by pain and weakness of the bitten limb. Later the sphincters and the muscles of the trunk are paralyzed. Death occurs from paralysis of the muscles of respiration. The heart may continue to beat, if artificial respiration is performed, for many hours after natural breathing has ceased. In these cases the diagnosis may be difficult, but may be established certainly by the inoculation of animals.

Differential Diagnosis.—Rabies may be confounded with hysteria, tetanus, and strychnin poisoning. With hysteria when the patient has informed himself of the characteristic symptoms of hydrophobia, or when they are suggested to him by bystanders. The typical spasms of deglutition and respiration are not easy to feign, and these persons are apt to carry in their heads some of the popular fallacies in regard to the true disease. I recall such a case seen some years ago. The patient was a man who was brought to the Roosevelt Hospital in an ambulance, said to be suffering from hydrophobia. He seemed at first to be entirely unconscious of his surroundings. He wept copiously—a common symptom of hysteria. He had frequent repeated general convulsions, with opisthotonos, but during them breathing was carried on in a normal manner. His face was flushed, his pulse was rapid from violent exercise, his temperature was normal. He continually imitated the barking and growling of a dog. He seized pillows and the bedclothing in his teeth, and by pulling and shaking actually tore them to tatters. When suggestions were made by the bystanders as to true and fanciful symptoms of hydrophobia, he imitated each in turn. He growled and spat freely about, but did not attempt to injure the bystanders. He was put partly under the influence of chloroform, on emerging from which his symptoms disappeared.

Tetanus.—The incubation period of tetanus is usually much shorter than that of hydrophobia. (See Tetanus.) The muscular contractions begin nearly always in the masseter muscles. There is no lockjaw in hydrophobia. While convulsive seizures occur in tetanus, the muscles are not relaxed, but remain hard and rigid between the attacks. In tetanus, Risus sardonicus is present; absent in hydrophobia. Maniacal excitement does not occur in tetanus. Swallowing is usually possible during the early part of the disease.

Strychnin Poisoning.—The symptoms come on immediately after the ingestion of the poison. There are violent generalized spasms of all the muscles of the body, sometimes with cessation of respiration and cyanosis. There is

Risus sardonicus, absent in hydrophobia. There is complete muscular relaxation between the convulsions. In marked cases opisthotonos occurs with every convulsion. There is marked photophobia, and objects appear green. The intellect is clear throughout. The convulsions in strychnin poisoning continue only a few hours, or at most a day, ending in death or complete recovery.

ANTHRAX

Synonyms.—Malignant pustule; French, Charbon; German, Milzbrand; Wool-sorter's Disease.

Definition.—Anthrax is an acute infectious disease caused by inoculation with the anthrax bacillus—a rod-shaped bacterium forming spores outside the animal body.

Surgical Bacteriology.[1]—The bacilli occur in the blood and tissues of man or animals attacked by anthrax. They are from 6 to 8 μ long and about 1.2 μ broad, with square or slightly concave ends. They sometimes occur in long chains, frequently in pairs arranged end to end. They stain well with all the basic anilin colors, and by Gram's method, although a cautious application of the decolorizing fluid is necessary in order to avoid removing the gentian violet from many of the bacilli. On gelatin plates the colonies develop, in from twenty-four to thirty-six hours, as very wavy bodies, radiating from the center outward like locks of hair. In a day or two a liquefaction begins which slowly extends through to the bottom of the gelatin. In gelatin tubes an appearance is seen similar to that of the colonies in gelatin plates, the growth appearing along the needle track as a whitish line sending out radiating lines and presenting the appearance of an inverted fir tree, whitish, and accompanied by liquefaction slowly progressing downward from the upper portion of the gelatin. In agar plates the colonies are apparent twelve hours after incubation at a temperature of 37° C., under a low power, presenting this very marked wavy appearance. Under a high power the wavy appearance apparently radiates out, and terminates not in a point, but in a turn upon itself; so that it is probable that the entire colony is a thread twisted on itself. On the surface of agar there is a moist, profuse growth, slightly elevated, and whitish in color, showing the wreathed appearance that is seen in plate cultures. The colonies on blood serum are the same as on agar. In bouillon there appears a shreddy growth that later becomes more abundant, settling as a flocculent mass to the bottom of the fluid. On potato there is a thick, moist, whitish layer, without any special characteristics. The bacillus grows rapidly, producing spores, does not produce gas, liquefies gelatin slowly, does not produce pigment, is stained readily with any of the anilin colors, and usually by Gram's method, and is pathogenic to all susceptible animals.

For diagnostic purposes cover-glass preparations may be made from the fluid in the vesicles, or from scrapings of the incised pustule, and may be stained with watery solutions of any of the anilin colors, and by Gram's method. The bacilli are not usually found in the blood. Muir and Ritchie give a very wise caution that

[1] Quoted from H. C. Ernst, "International Text-Book of Surgery," vol. i, p. 37, Warren Gould.

the parts should be handled carefully and gently in attempts at diagnosis, otherwise the diffusion of the bacilli into surrounding tissues may be forced, and the condition greatly aggravated. Plate cultures should also be made, as well as inoculations, if positive results are not obtained by the microscope alone.

Occurrence.—Anthrax occurs most often among the mammalia, including man, notably among the domesticated herbivora—cattle and sheep, less often horses. Animals dying of the disease and buried in a pasture become widespread sources of infection. The bacilli in the carcass form resistant spores, and may be disseminated over a large area by water, by wind, or mechanically. Thus an entire pasture or small watercourse may become infected, and epidemics of anthrax among stock often arise in this way.

Sources of Infection.—In animals, as in man, the disease may be acquired in three ways: (1) By local inoculation; (2) by entrance into the respiratory passages; (3) by ingestion, with food into the alimentary canal. In man the disease is commonly contracted from handling the hides and hair or bodies of animals infected with anthrax (wool-sorter's disease), so, also, by farmers, butchers, veterinary surgeons, and occasionally by pathologists or surgeons during experimental work in laboratories or during autopsies. Flies are believed also to transmit the disease. Infection through the use of imperfectly sterilized catgut has been reported (sheep's intestine). The *pustular* form of the disease by inoculation of a wound or abrasion of the cutaneous surface is much more common in man than is inoculation by inhalation or by the ingestion of infected food, although inoculation by inhalation does sometimes occur among those who sort wool. Recent wounds and abrasions of the integument not covered by granulations are the ports of entry. The exposed portions of the body are the usual seats—the face and neck, the hands and arms; lastly, the lower extremities.

Period of Incubation.—The period of incubation is two or three days, sometimes six, and usually without noticeable prodromal symptoms. The *pustule* develops first as a vesicle containing pinkish, later bluish, fluid, upon a slightly swollen, reddened or purplish base. The vesicle soon bursts and forms a crust of a black color, due partly to dried blood and partly to necrosis of the superficial tissues. The original pustule begins of the size of a pea, or sometimes it is as large as a ten-cent silver piece. The swollen edges of the pustule rise above the level of the skin, and the central crust appears depressed. The swelling and redness spread, and an areola of secondary vesicles is formed upon the inflamed skin. The subjective sensations of burning, itching, and tenderness are present. There is at this time moderate constitutional depression and a moderate rise of temperature. There is rapid swelling, edema, and induration of the surrounding skin and swelling of the communicating lymphatic glands. If the central scab be removed at this time a necrotic ulcer is exposed, discharging a thin, blood-stained fluid containing usually numerous anthrax bacilli, which can be recognized, by staining, under the microscope.

Variations in the Course of the Disease.—The subsequent progress of the disease varies a good deal in different cases. In some the pustule may have existed for several days without the anthrax bacilli leaving the immediate vicinity of the pustule, where they may be found, for the most part in the more superficial layers of the true skin. In one of my own cases excision of the pustule was made on the fifth day, and the bacilli were closely grouped around the original pustule and absent from the outer portions of the section. In other cases a very rapid dissemination takes place without much redness of the skin, but with rapidly progressive brawny edema and profound constitutional poisoning, ending in three to five days after the beginning of the disease in death, preceded by prostration, high fever, delirium, diarrhea, and collapse.

Infection through the lungs runs the course of an intense, septic, and rapidly fatal pneumonia. Intestinal infection is characterized by symptoms of sudden and violent inflammation of the alimentary canal with vomiting, diarrhea, and speedy death in collapse.

Diagnosis.—The diagnosis is established in ordinary cases by the characteristic appearance of the pustule and by recognition of the anthrax bacilli in the discharge, or in scrapings from the pustule, or in sections of the tissue under the microscope after the pustule has been excised, or by inoculations of animals.

It is a mistake to suppose that in man the diagnosis of anthrax can be made from examining the blood from the general circulation for anthrax bacilli. Only in exceptional cases of anthrax of a septicemic type and at a late stage can the bacilli be developed from blood cultures. In most instances cultures made from the blood remain sterile. (Ewing.)

It is well to remember, however, that not every pustule having a black scab at its center is anthrax. I have excised several which have been found to be due entirely to Staphylococcus pyogenes aureus. They lacked, however, the secondary vesication upon the skin surrounding the pustule. The diagnosis of those cases dying of pulmonary anthrax and of intestinal anthrax might be made before death by the recognition of the bacilli in the sputum or in the discharges from the bowel respectively, and in some instances by a history of exposure to the disease a probable diagnosis might be arrived at. A recognition *postmortem* in hardened sections of the liver, the lungs, and the spleen would reveal abundant characteristic bacilli embedded in the endothelial lining of the blood capillaries of these organs especially.

ACTINOMYCOSIS

Actinomycosis is a chronic infectious disease occurring in cattle and in man. It is caused by the growth in the tissues of the so-called ray fungus, an organism occurring in certain grains—notably in barley and in rye. The disease has in many instances been traced directly to inoculation with the

infected grain through some minute traumatism, and a spear or kernel of such grain has in certain cases been found embedded in or adherent to the diseased tissues. The disease in cattle is known as "lumpy jaw," on account of its localization and of the peculiar hard nodular tumors formed upon and in the neighborhood of the lower jaw of the infected animal. In the tissues of these nodules the fungus can be demonstrated invariably. In man the disease occurs somewhat rarely, and yet almost every surgeon of considerable experience has seen one or more cases. Infection from diseased animals has occurred, but is uncommon. The ingestion of infected meat has been thought in certain instances to account for the production of the disease; but probably in the majority of cases the disease is introduced, as has been many times demonstrated, through the medium of infected grain—barley, rye, wheat, or other cereal.

Avenues of Infection.—Three principal ports of entry are recognized—the mouth and throat, the respiratory tract, and the alimentary canal, occasionally through wounds of the external integument. When in the mouth and throat the fungus gains entrance through a carious tooth or through one of the crypts of the tonsil. Sometimes the inoculation takes place in the tongue or through some portion of the mucous membrane of the buccal cavity; probably more often in the gums, or between the teeth and the gums, than elsewhere. Undoubtedly the mouth is much the most frequent port of entry. In the lungs the infection takes place through aspiration of the fungus and inoculation through the lining membrane of the air passages. In the abdominal type, through the mucous membrane of the intestine. The cecum and appendix appear to be the regions most commonly attacked, but other portions of the gastro-intestinal canal may also be infected. Once inoculated, the disease tends to spread slowly by continuity of structure, but dissemination by the blood current is apparently possible, since pyemic forms of the infection have been observed with the formation of foci in widely separated organs.

Essential Lesion.—The disease is characterized by production of nodular masses of inflammatory tissue exhibiting in their structure a variety of lesions according to the relative age of the infection in different portions of infiltrated area. The older portions consist of dense hard masses of sclerosed fibrous connective tissue. In parts less ancient, the newly formed connective tissue is softer and is infiltrated with leucocytes. In the recent portions the masses of growing fungus are surrounded by granulation tissue, containing also giant cells. This granulation tissue tends to undergo purulent softening with perforation of the skin, and the formation of sinuses from which escape a thin purulent discharge containing minute granules of a gray, yellowish, or sulphur color, of such a size as to be visible to the naked eye.

The occurrence of these granules in the discharge constitutes the characteristic and diagnostic feature of the disease. The granules are often of the size of the head of a very small pin, or smaller; they are not always yellow in color; they may be colorless, like jelly, or dark, almost black, or greenish,

or white. When placed under the microscope these granules have a very characteristic appearance; they may be examined as they are, or stained with picric acid, or with any anilin stain—i. e., gentian violet or hematoxylin. They do not stain by Gram's method, except in the tissues of the ox. The masses are seen to consist under the microscope of a somewhat rounded body, toward the circumference of which are seen arranged in a radiating manner translucent filaments, frequently with enlarged or clubbed ends. These filaments may sometimes be seen to branch dichotomously. Sometimes small, rounded bodies may be seen scattered among the filaments; these are the spores or conidia of the fungus. The center of the mass is composed of an interlacing network of filaments. The diameter of the filaments is about 5 μ. A similar demonstration of the organism can usually be made in hardened sections of the affected tissues, surrounded by granulation tissue and giant cells or pus. By double staining of such sections with picric acid and fuchsin, the fungus then appears a brilliant yellow and the surrounding tissue cells red.

Clinical Diagnosis.—The recognition of actinomycosis clinically, as it occurs upon the FACE and NECK, is usually not very difficult. If the superficial soft parts are involved there will be found a chronically inflamed and nodular area upon the skin, sometimes over the body of the lower jaw, sometimes upon the neck; but little pain will usually be complained of, and the affection will have a markedly chronic history. The progress of the disease is, however, insidious and widespread; invasion by continuity of structure is not uncommon; thus, in actinomycosis of the upper jaw, the antrum, the base of the skull, and the temporo-maxillary fossa are invaded; in actinomycosis of the lower jaw, the soft parts of the neck, and even the mediastinum. There may be simply one or more indurated nodules or, more commonly, there will be found several nodules or parallel ridges elevated above the skin, some of which are broken down in their centers, the skin thinned, and fluctuating, suggesting somewhat the condition of an inflamed sebaceous cyst, or a subacute periosteal abscess, or, if the skin is already perforated, sinuses will be present from which may be extruded a thin watery pus, usually containing the characteristic actinomycotic granules; or an incision of one of the fluctuating areas will give escape to similar material.

If the disease involves, as it sometimes does, the CENTRAL TISSUES OF THE JAW, dilatation and enlargement of the jaw will be produced, later with perforation and the formation of sinuses. In such cases the infiltration of the tissues of the cheek will lead to more or less complete immobility of the jaw. In man this form of infection is less common and less characteristic than in animals. The cases have been mistaken for central sarcoma. Confusion may also arise when an epithelioma of the jaw becomes infected, breaks down and discharges pus containing white granules. In this instance the granules are epithelial pearls. In these cases the age of the patient, the presence of a primary growth on the skin or mucous membrane, or of a characteristic ulcer

in the mouth, and the rapid progress of the disease, will render the diagnosis clear, and yet I have seen good surgeons err in similar cases.

Upon the tongue the disease occurs as one or more indurated nodules usually not larger than a pea, which may break down, leaving a small cavity lined with yellowish necrotic tissue, or with somewhat indurated granulation tissue. In one case which I saw, in the clinic of Albert in Vienna in 1887, the disease existed in the form of multiple nodules upon the dorsum of the tongue, scattered over nearly the anterior half of the organ; from the discharge and from scrapings from the nodules the fungus had been demonstrated.

Actinomycosis of the Lung.—Actinomycosis of the lung is the gravest form of the disease; it presents the signs and runs the course in many instances of ordinary chronic pulmonary phthisis of a severe type, and is usually complicated by septic symptoms due to mixed infection with pyogenic microbes.

Moderate leucocytosis has been observed in actinomycosis of the lung running an acute course—21,500 (Ewing). There is loss of flesh and strength, night sweats, sometimes hemoptysis. The pleura and the diaphragm are frequently involved, and the disease may perforate the thoracic wall, and appear as an indurated area, or an abscess upon the thorax, usually low down; or the diaphragm may be perforated, and the peritoneum infected, with a rapidly fatal result. The diagnosis in these cases must rest upon the recognition of the fungus, either in the sputum or in fluid aspirated from the pleura, through a large needle. The continuous absence of tubercle bacilli in the sputum, the signs and symptoms of acute pleuritis with marked fever of a septic type, and the negative results of aspiration, or the withdrawal of merely serous fluid from the pleural cavity, together with a boardlike induration of the soft parts of the thorax, and repeated careful examination of the sputum, are the means of diagnosis. If metastatic foci occur in distant regions their contents may clear up the diagnosis.

In abdominal actinomycosis there are produced the symptoms of very varied disturbance of the alimentary tract. Pain, of a colicky character, sometimes diarrhea. The pains are sometimes localized and sometimes general. There are a variety of other irritative symptoms in special cases, depending upon the organs involved. An abdominal tumor or induration can usually be distinguished; this may simulate carcinoma of the cecum (the usual site) or other portion of the gut, or intestinal tuberculosis. In a certain number of cases involvement and perforation of the abdominal wall may take place with the formation of a dense infiltration of the tissues, sometimes with the escape from the sinuses formed of the characteristic fungus. The granules may also be discharged through the rectum or through the bladder. Other and varied localities in the body may be affected by this disease. The diagnosis will depend, as in other instances, upon the slow and often rather painless progress of the condition, by the formation of characteristic areas of indurated tissue, disseminated spots of softening, the formation of sinuses, and the rec-

ognition of the fungus in the discharge or in the infected tissues. (See Abdomen.)

Differential Diagnosis.—Actinomycosis of the tongue is to be distinguished from carcinoma of that organ by the situation. Cancer more commonly begins on the side of the tongue, actinomycosis near the tip. Cancer of the tongue is exceedingly painful, actinomycosis is not. Progressive ulceration and early involvement of the lymphatics of the submaxillary triangle are typical of carcinoma; they are absent in actinomycosis, or at least not marked. Gummata of the tongue are usually larger than the nodules formed by actinomycosis, they begin in the submucous tissue, and when broken down the crater-like appearance of the excavation lined by characteristic gummatous tissue should, when taken in connection with the history and the possible presence of other evidence of the disease, serve to distinguish them from actinomycosis. The administration of iodide of potash would not serve as a means of differentiation between these two conditions, because either process might be cured thereby. Tuberculous ulcers of the tongue occur usually in the presence of tuberculosis of the lungs; they are soft ulcerations, frequently with a caseous basis, or covered with flabby granulations. They are exceedingly tender and painful. The recognition of tubercle bacilli in the scrapings of the ulcer is usually not difficult.

Identification of Actinomycosis by Cultures.—The following is quoted from *The Journal of Medical Research*, vol. xiii, No. 4, May, 1905, "The Biology of the Micro-organism of Actinomycosis," by James Homer Wright, M.D.:

As the result of my experience I would recommend the following procedure for the isolation of the micro-organism of actinomycosis. The granules, preferably obtained from closed lesions, are first thoroughly washed in sterile water or bouillon and then crushed and disintegrated between two sterile glass slides. If one is working with a bovine case, it is well to examine microscopically the disintegrated material after mixing it with a drop or two of bouillon under a cover-glass to see if filamentous masses are present. If they were not, or if they are very few, proceed no further, but begin again with another granule, because the granules in bovine lesions sometimes contain no living filaments at all, but may be composed entirely of degenerate structures from which no growth of the micro-organism can be expected. If filaments and filamentous masses are thus found to be present in the granule, then the disintegrated products of the granule are to be transferred by means of the platinum loop to melted one-per-cent dextrose agar contained in test-tubes filled to the depth of about 7 or 8 cm. which have been cooled to about 40° C. The material is thoroughly distributed throughout the melted agar by means of the loop, and the tube then placed in the incubator. Several tubes should thus be prepared. At the same time a number of granules, after thorough washing in sterile water or bouillon, should be placed on the sides of sterile test-tubes plugged with cotton and kept at room temperature in the dark.

The sugar agar tubes inoculated as above described should be examined from day to day for the presence of the characteristic colonies in the depths of the agar. If very many colonies of contaminating bacteria have developed in the

tubes, it will probably be very difficult or impossible to isolate the specific micro-organism. If there are few or no contaminating colonies, then the colonies of the specific micro-organism should be expected to develop in the course of two or three days to a week. If a good number of living filaments of the micro-organism have been distributed throughout the agar, the specific colonies that develop will be very numerous in the depths of the agar, especially throughout a shallow zone situated about 5 to 12 mm. below the surface of the agar-agar.

When the presence of the characteristic colonies has been determined, slices or pieces of the agar containing colonies are to be cut out of the tube by means of a stiff platinum wire with a flattened and bent extremity. A piece of the agar is to be placed on a clean slide and covered with a clean cover-glass. It is to be examined under a low power of the microscope, and an isolated colony selected for transplantation. By obvious manipulations, under continuous control of microscopic observation, the selected colony together with a small amount of the surrounding agar-agar is to be cut out, care being taken to be sure that no other colony is present in the small piece of agar-agar containing the colony. The small piece of agar thus cut out should not have a greater dimension of more than 2 mm. The piece of agar is then transferred from the slide by means of a platinum loop to a tube of sterile bouillon, where it is thoroughly shaken up in order to free it from any adherent bacteria. If there be reason to believe that the small piece of agar has been very much contaminated with bacteria it should be washed in a second tube of bouillon; then the piece of agar is to be transferred by means of the platinum loop to a tube of melted sugar agar cooled to 40° C. It should be immersed deeply in the agar and the tube placed in the incubator. If the colony thus transferred to the agar-agar is capable of growth, in the course of some days it will have formed a good-sized colony from which transplants in various culture media may be made.

In the manner described several small pieces of agar containing single isolated colonies should be placed in sugar agar tubes, because the chances are, as already stated, that some of the colonies will not grow, and contaminations with other bacteria may occur.

If the number of contaminating colonies is so great in the original agar cultures from the granules that it is found impossible or very difficult to obtain specific colonies free from other micro-organisms, then it is probably not worth while to expend much labor with the task of isolation from these original agar tubes, but it is much better to wait until the granules placed on the sides of sterile test-tubes have dried thereon for two or three weeks and then proceed with these granules as just described for the fresh granules. The drying of the granules for this length of time will probably suffice to kill off most of the contaminating bacteria and enable isolated colonies of the specific micro-organism to be obtained in the agar suspension cultures.

MADURA FOOT

Synonyms.—Mycetoma; Fungus foot of India.

Closely allied to, if not identical with, actinomycosis is a disease occurring endemically in certain parts of India, notably in the neighborhood of

the city of Madura in southern India, although not confined to this region, since cases occur in other countries, and have been described in Italy and both North and South America. The disease is essentially a chronic suppurative process beginning beneath the integument of the sole or dorsum of the foot, and later involving the deeper parts, muscles, tendons, and bones. Sinuses are formed which discharge pus and the characteristic rounded masses of fungi, either white or black in color. The sinuses result from the breaking down of hard nodules, precisely as is the case in actinomycosis. The disease is very chronic and gradually involves all the tissues of the foot. Owing to disuse, the muscles of the leg undergo atrophy and the limb becomes a useless appendage. The disease is usually not painful. The diagnosis is to be made from the swelling, the hard nodules, the sinuses, and the recognition of the characteristic nodules, which under the microscope are hardly to be differentiated from actinomycosis.

ERYSIPELOID

Synonyms.—Erythema Migrans; Rosenbach's Erysipeloid.

An acute inflammatory affection of the skin of the fingers and hand, characterized by the formation of sharply defined red or bluish-red swollen areas upon the skin, attended by the subjective sensations of burning and itching. Constitutional symptoms are wanting. The disease is caused by inoculation of minute wounds or abrasions of the fingers or hand with bacteria. Whether the disease is produced by a specific germ or may be caused by several kinds of bacteria is not entirely clear. As originally investigated and described by Rosenbach, the disease was caused by a form of coccus, which when inoculated in pure culture reproduced the disease. Later, Cordua found in the lesions a coccus resembling in its mode of growth Staphylococcus pyogenes albus, but the individual cocci were several times larger than Staphylococcus albus. He also reproduced the disease by inoculation of cultures on his own person.

The disease is one very commonly observed in dispensary practice in cities, and affects chiefly those who handle fish, shellfish, game, and meat—i. e., cooks, butchers, cleaners, and handlers of fish and game, oysters, etc. The disease begins as a patch of infiltration on a finger or knuckle, and spreads toward the hand. Sometimes several fingers or the whole hand as far as the wrist may be the seat of the lesion. The inflamed patches are bright red or bluish red, swollen, elevated, sharply defined from the surrounding skin, and tender. The disease may last for days, or even a fortnight or longer. Suppuration does not occur. Itching and burning are present. The affection presents some resemblance to mild degrees of frostbite of the fingers, but the redness is more sharply defined, and spreads by continuity of structure, nor does ulceration take place. The occupation of the individual gives valuable aid in the diagnosis.

GLANDERS

Synonyms.—Farcy; German, Rotz; French, Morve; Farcin; Malleus humidus.

Glanders is an infectious and contagious disease occurring chiefly in horses, and characterized by the formation of nodules of granulation tissue on the mucous membrane of the respiratory tract and upon the skin, containing the bacilli of the disease. The nodules break down into ulcers. Lymphangitis and embolic infection of distant organs are a regular accompaniment of the general infection. It is communicable to man and also to most of the domesticated animals, but not to the ox. The cause of the disease is a rod-shaped bacillus about 1-2 μ in length, with rounded ends. The bacilli are nonmotile, and do not produce spores. They are quite sensitive to heat and to antiseptics, and are killed by drying after two weeks.

The best culture material is blood serum at body temperature.

According to Muir and Richie, the bacilli may best be stained in carbol-thionin blue stock solution 1 gm., thionin blue in 100 c.c., carbolic acid of a strength 1–40. Dilute 1 part with 3 parts of water and filter. Stain sections for five minutes or upward. Wash very thoroughly in water to prevent later deposit of crystals. Decolorize with very weak acetic acid (a few drops to a glassful of water). Wash thoroughly in water. Dehydrate and clear with anilin oil and xylol equal parts and then with xylol. This bacillus does not stain with Gram's method. (Ernst.)[1]

In acute cases the bacilli can sometimes be isolated from the blood a few days before death. Thus, Ewing and Coleman report a case of acute glanders in man with extensive involvement of the lungs in which bacilli were isolated from the blood three days before death. Noniewitch reports the same of fatal cases in horses. The bacilli were found usually within the leucocytes. Moderate leucocytosis, 13,000, has also been observed.

Diagnosis.—A ready and simple method of making the diagnosis in a suspected case of glanders is to inoculate the discharge or scrapings from the suspected lesion into the subcutaneous tissues of the abdomen of a male guinea pig. The testicles of the animal will become much enlarged within twelve hours to three days, if the bacilli are present; and glanders bacilli may be demonstrated in the testes themselves as well as abscesses in some cases. Another test for the presence of the disease consists in injecting into the tissues of a horse suspected of having the disease a substance known as mallein, prepared from the filtered cultures of the bacillus of glanders grown upon artificial media and containing the toxins of the disease, but no bacilli. If a suitable quantity of this material be injected into the tissues of an animal or man affected with glanders, a rise of temperature occurs, amounting in the case of the horse to 2° C. or more. This test is said to be accurate in from seventy-

[1] "International Text-Book of Surgery." Warren Gould

five to ninety per cent of cases. In the horse as well as in man the disease occurs in an acute and a chronic form.

Symptoms.—The symptoms and course of the disease in the horse are thus described by Youatt:

The earliest local symptom is a nasal discharge, which consists of an increased secretion, small in quantity, and flowing constantly. It is of an aqueous character, mixed with a little mucus. It is not sticky when first recognized, but becomes so afterwards, having a peculiar viscidity and glueyness. The discharge soon increases in quantity, and in the advanced stages becomes discolored, bloody, and offensive. On the other hand, the disease may continue for many months, or even for two or three years, unattended by any other symptom, and yet the horse be decidedly glandered. The glands under the jaw soon become enlarged, and are generally observed on the same side as that on which the nostril is affected; the swelling at first may be somewhat large and diffused, but this subsides in a great measure and leaves one or two glandular enlargements, which become closely adherent to the jaw-bone. The mucous membrane of the nose becomes of a dark-purplish hue, or almost of a leaden color—never the faint pink blush of health, or the intense and vivid red of usual inflammation. Spots of ulceration will probably appear on the membrane covering the cartilage of the nose; these ulcers are of a circular form, deep and with abrupt and prominent edges, and become larger and more numerous, obstructing the nasal passages, and causing a grating or choking noise in breathing. The disease extends upward into the frontal sinuses, and the integument of the forehead becomes thickened and swollen, causing peculiar tenderness. The absorbents about the face and neck now become implicated, constituting farcy; these enlarge and soon ulcerate. The absorbents on the inside of the thigh, and then the deep absorbents of both hind legs, are next involved, causing the parts to swell to a great size, and to become stiff, hot, and tender. The constitutional symptoms are loss of flesh, impaired appetite, failing strength, and more or less urgent cough; the belly is tucked up; the coat is unthrifty and readily comes off. The animal soon presents one mass of putrefaction, and dies exhausted.

Glanders in Man.—In man the characteristic feature of the disease is the formation of nodules chiefly upon the mucous membrane of the respiratory tract and upon the skin of various regions; the nodules are small at first, varying in size from that of a small bird shot to that of a pea. They are whitish or yellowish in color, are surrounded by an inflamed border, are sometimes umbilicated, and tend rapidly to break down, forming ulcers which spread in size and depth. Secondary involvement of distant organs takes place apparently through the blood current; and the abdominal viscera, the lungs, the bones, the testes may all be involved with the production of nodules and of diffuse infiltrations. When the skin is the seat of the infection a similar process occurs, nodules are formed which rapidly soften, and are followed by progressive and destructive ulceration. The nodules commonly form along the course of the lymphatic channels (farcy buds). In man the disease may run a very rapid course under the guise of a septicemia or septic

pneumonia with typhoid symptoms, and death may occur in a few days or a fortnight.

Modes of Infection.—The diagnosis may be difficult or impossible without a clew furnished by the occupation of the individual or a history of exposure to infection from a diseased animal. Coachmen, farriers, cavalrymen, and those in general who have much to do with horses are most often attacked. The modes of infection are various. The infectious material may be blown or coughed into the face by the diseased animal, or minute wounds may be infected by handling the horse or his harness or clothing. Thus the infection may take place through or near the mucous membrane of the nose (glanders) or through the external integument (farcy). According to these two different modes of infection and progress the disease may be divided into two types—glanders and farcy—each acute and chronic, although combinations of the two types of the disease may, of course, occur.

Acute Glanders.—In acute cases the period of incubation is three or four days. The disease begins with general malaise, a febrile movement, and general pains. There is swelling, redness, and often lymphangitis at the site of inoculation. Within a few hours or a day nodules are formed in the mucous membrane of the nose; these rapidly ulcerate and purulent discharge occurs from the nares. Secondary involvement of the skin of the face and of distant parts occurs and a pustular eruption is developed upon the face and on the extremities, notably about the joints. The pustular eruption goes on to ulceration, and the ulcers may become necrotic and offensive. The disease has been mistaken for small-pox. The lymphatics of the neck are much swollen. Acute purulent arthritis of the larger joints as a metastatic process occurs in some cases. The joint becomes red, swollen, painful, tender, and distended with purulent fluid. Secondary involvement of the lungs produces a septic pneumonia, and the abdominal organs and kidneys often become involved through the blood current. Death is invariable in this form of the disease, usually in less than a fortnight.

Chronic Glanders.—The chronic form of the disease in man is rather rare, and may be very hard to recognize. There is not the same tendency to ulceration which occurs in acute cases, and the lesions resemble tuberculosis in that they tend to undergo caseation. They may be confounded also with gummata or even with actinomycosis. The localization of the process in the nose is by no means as frequent in man as in the case of the horse. The process may last for months or even years; a mortality of fifty per cent attends this form of the disease. The diagnosis depends, as in acute cases, upon recognition of the bacilli in the discharge, in scrapings or sections of tissue, and in inoculation of animals, as before mentioned.

CHAPTER IV

SURGICAL TUBERCULOSIS AND DIAGNOSIS OF DISEASES OF JOINTS

SURGICAL TUBERCULOSIS

The forms of tuberculosis interesting to the surgeon are, especially: Tuberculosis of the skin and mucous membranes; of the lymph glands; of the tendons and tendon sheaths, bursæ and muscles; of the bones and joints; of serous membranes, notably of the peritoneum and pleura; of the genito-urinary organs, the breast, the thyroid gland, and the testicles. (For tuberculosis of serous membranes and of organs, see Regional Surgery.)

Clinical Diagnosis of Tuberculosis.—The clinical diagnosis of tuberculosis is usually possible without the identification of the tubercle bacillus, but there are a number of conditions in which a recognition of tubercle bacilli—either in discharges, in excretions, or in tissues—is almost indispensable for a positive diagnosis, and necessary before intelligent surgical treatment can be planned. I shall accordingly dwell upon the methods of examination of various kinds of material for tubercle bacilli at some length. While tubercle bacilli exist in all the lesions of the disease, yet under certain conditions their recognition is difficult by microscopic examination, and we are then obliged to resort to inoculation of the suspected material into the bodies of susceptible animals (usually guinea pigs are selected) in order to demonstrate conclusively the existence of the disease.

Laboratory Identification of Bacillus Tuberculosis.—The tubercle bacillus may be recognized by its staining reactions under the microscope and by its behavior in culture media. The following technical description is that of Ernst:[1]

The bacillus of tuberculosis occurs in all lesions of the disease. It is a small rod, on the average from 2.5 to 3.5 μ in length and 0.3 μ in breadth. It occurs singly or in pairs, arranged either end to end or like the arms of the letter V. It is nonmotile. The unstained portions of the rod have been by some supposed to be spores, but this is not generally accepted. It does not grow upon ordinary gelatin or upon ordinary nutrient agar. It does, however, develop upon both of these media if from six to eight per cent of glycerin have been added to them. Its best growth, however, is found upon blood-serum at the temperature of the body. On this medium its colonies present a characteristic appearance. They are seen first as small brownish-yellow dots, and never before the eighth or

[1] H. C. Ernst, "International Text-Book of Surgery," vol. i, p. 35. Warren Gould.

ninth day. They increase in size, coalesce, and form a heavy, wrinkled, dirty-brown or cream-colored layer extending outward three or four lines on each side of the needle-track, and in undisturbed cultures grow upon the surface of the water of condensation, leaving the fluid below perfectly clear. Once seen, these colonies are almost unmistakable for anything else. The growth upon potato, which is sometimes seen, but not always, presents similar characteristics. The bacillus is of slow growth, develops only at the temperature of the body, does not liquefy gelatin, probably does not produce spores, produces no gas or odor, stains with difficulty with the ordinary anilin colors, decolorizes with equal difficulty, and produces tuberculosis upon inoculation in all susceptible animals. The difficulties in cultivating the bacillus of tuberculosis would present an almost insuperable obstacle to the diagnosis of tuberculous processes by this method. Fortunately, however, Ehrlich showed that this bacillus has a special staining reaction by which it may be differentiated from any others with which it is likely to be confounded. Taking advantage of the resistance of this bacterium to the decolorizing action of the mineral acids, Koch and Ehrlich worked out a differential stain, than which no better method has ever been suggested for the detection of small numbers of the bacilli in suspected material. For cover-glasses this method is as follows:

1. Cover-glasses prepared in the usual way are stained overnight—better for twenty-four hours—in anilin-water fuchsin (or gentian violet). 2. Transfer at the end of that time to nitric acid (1:4) for a few seconds. 3. Place in sixty per cent alcohol for one minute to complete decolorizing. 4. Wash in water. 5. Stain in watery methylene blue (or vesuvin, if gentian violet was the first stain used) for one to two minutes; wash thoroughly; dry carefully; mount in oil of cedar or Canada balsam.

Sections are stained in precisely the same way, with the exception that in place of the nitric acid, 1 part to 4, a little stronger bath of nitric acid is used, 1 part to 3, because, the sections being thicker than the film on the cover-glass, a somewhat stronger decolorizing agent is necessary. Of course, after the washing following the use of the methylene blue, the sections are to be dehydrated, cleared in oil of cedar, and mounted in Canada balsam.

The efficiency of this stain lies in the fact that the nitric acid appears to exert some direct coagulant (?) action upon the capsule of the bacillus itself. This action is practically instantaneous, and results in placing the capsule in such a condition that it resists the further decolorizing action of the nitric acid, so that the bacillus remains stained. This is not true with other bacilli; all other bacteria are completely decolorized, except the bacillus of leprosy and the smegma bacillus; and if the source of the material allows any possibility of confusion with these two, the method of differentiation already given will serve to put an end to any doubt. (See Tubercle Bacilli in the Urine.)

The method as given by Koch suggests the use of gentian violet as the first stain (with fuchsin as the second choice) and vesuvin as the contrast stain (with methylene blue as the second choice), the result of which would be, of course, a blue-stained body upon a brown ground; while the method preferred here gives red-stained rods upon a blue ground. This is the result that has been found by far the most useful, for it is much more easy for the eye of the average student to detect a minute red body upon a blue ground than it is to find a minute blue body upon a brown ground. Much objection is constantly raised to this method

of staining because of the time that must elapse before the material is ready for the microscope, and innumerable short ready methods have been suggested, not one of which is as reliable as this, but many of which are much more used.

The most common of these is the so-called Ziehl's method. In this method, as in the others, advantage is taken of the resistance of the bacillus of tuberculosis to decolorizing agents. As in the first method given the anilin oil is used as a mordant to intensify the action of the first stain, so in this method the aid of a still stronger mordant is sought and found in carbolic acid. The first procedure in the Ziehl-Nielsen method, which is applicable only to cover-glasses, is as follows: Cover-glasses prepared after the usual method are stained in carbol fuchsin for thirty minutes (this time may be shortened to ten minutes by warming the staining fluid); decolorize in sulphuric acid (1 part to 4) for a few seconds; wash in water; a contrast stain is obtained by watery methylene blue for two or three minutes; the cover-glasses are then thoroughly washed in water, carefully dried, and mounted. In this method, as there is a stronger mordant used in the carbolic acid, so there is a stronger decolorant used in sulphuric acid. Experience has demonstrated that while this stain may be useful for showing the presence of large numbers of bacilli, it cannot be relied upon when there are but few. Of this method, as of all the short methods yet presented, it may be said that if one finds rods stained red on a blue ground, the presence of the bacilli may be acknowledged; yet if such rods are not found, the absence of the bacilli cannot with safety be asserted.

Gabbet's method of staining is one frequently used, combining the decolorizing and the second stain. 1. Stain cover-glasses with carbol-fuchsin, hot, for one minute. 2. Wash in water. 3. One half minute in Gabbet's methylene blue (methylene blue, 2; sulphuric acid, 25; water, 75). 4. Wash thoroughly, dry, and mount.

In examining suspected material for purposes of diagnosis in tuberculosis, cover-glass preparations are to be made in quite large numbers, and thoroughly studied after being stained by one or more of the methods suggested; but inoculation experiments are sometimes successful when the microscopic examination fails, so that recourse should be had to these inoculation experiments if the matter of diagnosis is one of importance and the microscopic examination has failed to demonstrate the bacilli. Inoculation experiments are more commonly necessary in the diagnosis of surgical tuberculosis than in other forms of the disease. The bacillus being more often present in the granulations and lining membranes of abscess cavities, it is to be looked for especially in these tissues rather than in the contained fluid.

Clinical Diagnosis of Surgical Tuberculosis.—The clinical diagnostic features of surgical tuberculosis in general are the formation of tubercular tissue in the form of miliary and submiliary tubercles, or of larger areas of tubercular infiltration in tissues and organs; a tendency of the tubercle tissue to undergo caseation and subsequent softening and liquefaction; a very chronic course; absence of the signs of acute inflammation; a tendency to invade neighboring structures and to progress along the lines of least resistance—notably along intermuscular planes by the force of gravity—or to break through the articular ends of bones into joint cavities, and in some instances to produce a general infection of the organism.

Tuberculosis of the Skin

Lupus.—The most common form of tuberculosis of the skin is lupus. The disease commonly occurs in youth and early adult life. It affects the face more often than the extremities, more rarely the trunk; the arms, from the elbow to the fingers, more often than the legs; the dorsal surfaces and neighborhood of joints rather than the palms or soles. Upon the face, the nose is the most frequent starting point of lupus, and the ala of the nose is often first affected.

Characteristics.—The characteristic sign of the disease is the *lupus nodule*, a circumscribed rounded infiltration of the true skin, of a reddish-brown, pink-brown, or yellow-brown color, and an "apple-jelly," or semitranslucent, appearance, of varying size, rather soft in consistence. Upon pressure the color of the nodule becomes paler, but some color remains. The nodule is on a level with the surrounding skin (Lupus maculosus), and may remain so. Such nodules vary in size from that of the head of a small pin to that of a No. 2 shot.

Course.—The disease pursues a very chronic course, and the surface of the nodule after a time becomes covered with dry scales (Lupus exfoliativus). Degenerative changes take place in the nodule; it breaks down and ulcerates (Lupus exulcerans, Lupus excedens), or undergoes atrophy and is replaced by cicatricial tissue. The presence of one nodule is usually followed by the development of others in the neighborhood. The disease is prone to advance at the periphery, while the older portions undergo atrophy or more or less complete cure. If many nodules coalesce, a considerable mass of tuberculous tissue may be formed, with cell infiltration of the deeper structures (Lupus hypertrophicus). Very often the several processes go on hand in hand in the same lesion. *The ulcerative form of lupus* causes notable destruction of tissue. On the face, the nose may be more or less completely destroyed. The ala, the tip of the nose, and the cartilages suffer rather than the bones, and the nose has the appearance of having been cut off. Syphilis, on the other hand, produces bone destruction and a sunken or so-called saddle nose. The lips, the cheeks, the forehead may all be involved with the production of hideous deformities. The ulcers are commonly covered with crusts made up of cheesy material, broken-down tubercle tissue, and the dried discharges of ordinary purulent infection—a regular coexistent lesion in these cases.

Diagnostic Features of Lupus.—The characteristic nodules in the skin, the chronic course, the tendency to serpiginous advance of the disease, the formation of cicatricial tissue in the older portions of the lesion while new nodules and ulcerations are present at the advancing border, the situation, are the important diagnostic features. The lesions are usually not painful. Upon removing the crust from ulcerated areas, minute grayish or white points may be distinguished upon the raw surface; these are miliary or submiliary tubercles undergoing degenerative changes. They bear a slight resemblance to the

epithelial masses seen upon the surface of an ulcerating epithelioma. These latter, however, can readily be expressed from the raw surface, and under the microscope are easily seen to consist of masses of epithelial cells. It is to be remembered that epitheliomatous degeneration of areas long affected by lupus is not an uncommon occurrence.

Verruca necrogenica (Anatomical Tubercle).—This variety of tuberculosis of the skin is due to direct infection. The disease occurs most commonly upon the dorsal surfaces of the fingers and hands of pathologists and their assistants. A red elevated nodule appears at the site of inoculation, and slowly increases in size; the nodule is rather firm on palpation, usually painless, or but slightly painful. The central portion soon breaks down, creating a small ulcer covered by a scab; upon removing this several small orifices are seen in the tubercular granulation tissue; from these a little pus may be made to exude by pressure. Later, papillary outgrowths take place, producing a wartlike appearance. The occupation of the individual, the very chronic course, and the characteristic appearances, render the diagnosis easy.

Tuberculosis verrucosa cutis.—Under this name, Riehl and Paltauf, in 1886, described a tuberculosis of the skin characterized by the formation of patches of tubercular infection of the cutaneous surface varying in size from three fourths of an inch to two inches in diameter. The disease is very chronic, and the infected areas are sensitive and sometimes painful. As described, the patch exhibits three zones: an outer red border of erythema, within that a circle of small pustules, often covered by scales, and a central area covered by papillary outgrowths.

Secondary Tubercular Infections.—Secondary tubercular infections of the skin occur as the result of the spread of deep-seated tubercular lesions, notably of the lymph nodes, the bones, and the joints. Softening of the tubercular tissue is followed by the formation of a tuberculous abscess which tends to advance by pressure toward the surface. The skin finally becomes infected from within, softens, and breaks down. Tuberculous material is discharged and a tubercular ulcer or sinus remains, according to local conditions. The appearance of these lesions is characteristic. The skin edges of the orifice are rounded or irregular in contour, have a worm-eaten appearance, are of a blue or purple color, and a soft, friable consistence when the perforation is recent. Often several orifices exist separated by bridges of blue, thinned-out and friable skin. The cavity is lined by pale granulation tissue, showing here and there upon its surface yellowish areas of caseous material.

After a time exuberant tuberculous granulations are prone to form and to become elevated above the level of the skin. The appearance of these at the orifice of a tuberculous sinus has been likened to a fold of prolapsed mucous membrane. Cicatricial tissue in abundance is thrown out by the surrounding tissues, and after a time these orifices come to be surrounded by a dense, hard, fibrous wall, and later, by the contraction of such tissue, the orifice comes to be depressed below the level of the skin. The discharge from

such sinuses varies in character. Upon the rupture of a tuberculous abscess a rather pale yellow or white creamy material escapes, containing cheesy masses.

This so-called *tuberculous pus* is of characteristic appearance; it is found under the microscope to consist, not of pus cells, but of granular material containing much fat—the result of the degeneration of the tuberculous granulations. Tubercle bacilli cannot usually be demonstrated in the material, although when inoculated into susceptible animals tuberculosis follows. After the abscess has once emptied itself the discharge diminishes in quantity, becomes scanty, often thin and watery. Secondary infection with pus microbes often occurs, and the picture then changes to one resembling ordinary suppuration with the discharge of true pus. The bacillus pyocyaneus is a not infrequent invader of these sinuses. The dressings are then stained with the characteristic green discharge, and a musty odor is present.

Tuberculosis of Mucous Membrane

Primary tuberculosis of the readily visible mucous membrane is rather uncommon. *Secondary infection* of mucous membranes is common. *Tuberculosis of the mucous membrane of the nose* is sometimes the starting point of lupus of the face.

Tuberculosis of the Posterior Pharyngeal Wall and Soft Palate.—This occurs occasionally during childhood, puberty, and adolescence among individuals already the subjects of tuberculosis of the lungs. Submiliary tubercles occur, and break down into shallow ulcers with a cheesy base. Such ulcerations may be confounded with syphilis. The tubercular process is, however, attended by less destruction of tissue, is more painful, tends to spread superficially, and to undergo later cicatricial contraction.

Tuberculosis of the Tongue.—Tuberculosis of the tongue occurs in individuals with tuberculosis of the lungs. The ulcer is usually rounded or oval, tender and painful, the base covered with yellow, caseous material or with exuberant pale, fungating granulations. Infiltration and hardening of the base of the ulcer may lead to the suspicion of cancer. The presence of lung tuberculosis, the very chronic course, and the microscopic examination of fragments of diseased tissue—removed by scraping or with the knife—serve to clear up the diagnosis.

Tuberculous Ulceration of the Rectum.—A considerable proportion of all cases of fistula *in ano* are tubercular. These fistulæ are often associated with tuberculosis of the lungs. They are characterized by their chronic course; by the production of fungating granulations; often by undermining of the mucous membrane of the gut; by the formation of ulcerated areas of considerable size; and by the occurrence of burrowing sinuses, whose skin orifices have the characteristic tubercular appearance. They are very apt to recur, or fail to heal, even after thorough operative removal. (See Rectum.)

Tuberculosis of the Lymph Glands

Tuberculosis of the Lymph Nodes.—One of the commonest forms of tubercular disease is tuberculosis of the lymph nodes. The condition was characterized by Billroth as "the daily bread of the surgical clinic." As is the case with other forms of tuberculosis, tubercular lymphomata occur most commonly during childhood, adolescence, and early adult life, but the condition is common enough at all ages. Of the superficial lymphatics, the glands of the neck, the cubital, the axillary, and the inguinal and femoral glands are *infected* in the *above order of frequency*. The mediastinal, mesenteric, and retroperitoneal lymph nodes are also frequently the seat of tuberculosis, but are of less surgical interest.

The infection may be primary, directly through the lymph current, the infection atrium not being apparent; or a catarrhal, ulcerated, or fissured condition of a mucous surface may permit the passage of the bacilli. In other cases infection takes place through the lymph channels from an existent tubercular lesion elsewhere. Infection through the blood current direct also may occur. The tonsils and lymphoid tissue of the nasopharynx are favorite portals of entry. Cutaneous irritations and eruptions upon the face and scalp, and carious teeth, often precede the glandular infection.

Fig. 23.—Tuberculosis of the Lymph Nodes of the Neck. (New York Hospital, service of Dr. Frank Hartley.)

Characteristics of Tuberculosis of Lymph Glands.—The disease is characterized by a slow, painless enlargement of the affected glands. Early in the disease the glands are discrete, movable, and may remain so indefinitely. In other cases periglandular inflammation occurs; the tumors then become adherent to the surrounding structures and to each other; they cease to be movable, and form smooth or nodular masses of considerable size. In some cases caseation occurs without rupture of the glandular capsule, and calcareous degeneration may take place; in this condition the tumors may remain quiescent indefinitely. More commonly softening and perforation of the glandular capsule occurs, and results in the formation of a painless, insensitive, fluctuating area, which finally

perforates the skin, as already described. Signs of acute inflammation are absent. In other instances a diffuse tubercular inflammation of the subcutaneous connective tissue and of the intermuscular and fascial planes results. The infection is also prone to advance from one gland to another, either slowly and insidiously or quite suddenly. After perforation of the skin has taken place, a tubercular ulcer or sinus remains behind. Such sinuses may remain open for years, may heal from time to time, only to break down again, or spontaneous cure may occur, often with the formation of ugly, puckered scars.

Differential Diagnosis of Tubercular Lymph Glands.—It is necessary to differentiate tubercular lymphomata from simple inflammatory hyperplasia, from primary sarcoma of the lymph nodes, from malignant lymphomata, pseudoleukemia, and from secondary carcinomatous infection. From simple inflammatory swelling, not accompanied by suppuration, the diagnosis is not always easy from a single observation. The presence of a superficial source of irritation—an infected wound, an ulcer, an inflammatory lesion of the skin—points to a simple inflammation.

Fig. 24.—Tuberculosis of Cervical Lymph Nodes, marked Periglandular Infiltration. (New York Hospital, service of Dr. Frank Hartley.)

In such cases the enlargement of the glands is moderate; the glands are usually neither tender nor painful; they are freely movable. Removal of the superficial source of irritation is followed by diminution in the size of the glands, though some enlargement may persist indefinitely. Such glands may subsequently become the seat of tuberculosis. If after removal of the external source of irritation the enlargement continues or increases, tuberculosis is probable. The gross and microscopic appearances of the glands, after removal, are usually characteristic, if tubercular. Bacilli may be found in the earlier stages; after softening and caseation have occurred their recognition may be difficult. Upon section, tuberculous lymph glands vary in gross appearance, according to the stage of the process. The cut surface may appear normal to the naked eye. Miliary and submiliary tubercles may show as grayish-yellow areas, distributed irregularly throughout the glandular substance. Considerable areas, or the entire gland, may be in

a state of caseation, of purulent softening, or even of calcification, if the process is ancient.

Malignant Lymphoma, Pseudoleukemia.—In the early stages of pseudoleukemia, occurring during the second and third decades of life, the differential diagnosis from tuberculosis of the lymph glands is not always easy. The tumor masses of tuberculosis are apt to be of *unlike consistency* in different parts; areas of softening, alternating with indurated masses of periglandular infiltration and with isolated nodules of varying size and consistence. The occurrence of glandular tumors in an individual with no predisposition to tuberculosis, with no signs of local irritation in the vicinity, and otherwise in apparent health, leads to a suspicion of possible leukemia. A steady increase in the size of the tumors, the sudden successive involvement of group after group of glands, and the appearance of similar enlargements in other regions, speaks for pseudoleukemia.

FIG. 25.—HODGKIN'S DISEASE—MULTIPLE GLANDULAR TUMORS IN THE NECK AND AXILLA. (New York Hospital, author's service.)

The tumors of pseudoleukemia are of *uniform consistency*; they are more apt to produce pressure symptoms. Gradual and serious impairment of the general health occurs after a time, and in some instances an irregular and intense fever makes its appearance from time to time, lasts for hours or days,

and disappears. Arsenic in large doses sometimes causes notable diminution in the size of the pseudoleukemia tumors. In some instances a microscopic examination of a gland, removed for the purpose, is necessary to clear up the diagnosis. The blood changes of true leukemia suffice to eliminate tuberculosis as a cause of the glandular tumors of the former disease. (For further information, see Tumors of Neck.)

Tuberculosis of the Tendons, Tendon Sheaths, Bursæ, and Muscles

Tuberculosis of the Tendons and Tendon Sheaths.—The condition may be primary in the tendons or their sheaths, or secondary to tuberculosis of the bones and joints of the affected region. The tendons of the forearm and hand—flexor and extensor—the peroneal tendons of the ankle, and the tendons about the knee are those most commonly involved, in the above order of frequency. Three forms of the disease are to be distinguished clinically.

1. A serous effusion occurs in the tendon sheath which may be sharply localized and form a rounded, elastic, fluctuating swelling along the course of the tendon—not to be distinguished from a simple hygroma (single or multiple ganglion)—or the effusion may occupy the entire length of the sheath, or, as at the wrist, the tendon sheaths of numerous tendons may be involved.

2. In the second form there is added to the serous effusion the formation of small pedunculated or free fibrinous masses—the so-called rice bodies—together with a gelatinous thickening of the wall of the sheath. A more or less elastic or fluctuating swelling is thus produced, corresponding in site to the course of the affected tendons.

3. The fungating form is characterized by the formation of tubercular granulation tissue in abundance, and a tendency to break down, with the formation of abscesses and sinuses. This condition is progressive, and may involve any neighboring structures, including muscles and joints.

The serous and fibrinous forms are exceedingly chronic, they are usually painless, except that moderate pain may accompany use of the affected tendons. There is slowly progressive loss of power and undue fatigue of the affected limb upon slight exertion. The disease may last for many years without leading to serious inconvenience. These two forms may rarely be converted into the third or fungating form. For the special diagnostic features of these conditions the reader is referred to Regional Surgery.

Tuberculosis of the Bursæ.—The bursæ may become infected with tuberculosis primarily or secondarily to tuberculosis of underlying bone. The former variety may closely resemble tuberculosis of the tendon sheaths with the formation of rice bodies. (See Tuberculosis of Tendon Sheaths.) The bursa becomes enlarged, its walls thickened; fluctuation will be more or less marked or nearly absent, the sensation given to the examining fingers being rather that of a sac containing semisolid material. Incision is usually necessary to establish a diagnosis unless a sinus is present. In that variety due to

tuberculosis of bone there is formed a thick-walled sac filled with tuberculous pus or granulation tissue, giving a sense of obscure fluctuation. There will be a history of some pain and tenderness in the underlying bone, a chronic course, and the gradual formation of a doughy swelling, usually of rounded or ovoid shape. Incision will establish the diagnosis. The differential diagnosis of the inflammations of bursæ will be found under Regional Surgery.

Primary Tuberculosis of the Muscles.—This is a very rare condition; it has been observed especially in the muscles of the upper arm as a dense hard infiltration of the muscular tissue resembling a new growth; the condition eventuates in a characteristic cold abscess. Tuberculosis of muscles and of fascial planes is a very common condition secondary to tuberculosis of bones and joints. The diagnostic features will be described under Regional Surgery.

Tuberculosis of Bone

Occurrence.—Tuberculosis of the bones is one of the most frequent forms of the disease. Most common in childhood and youth, but may occur at any age. The epiphyseal ends of long bones and the spongy tissue of short bones are the common seats of the process; less often the shafts of long bones. Multiple foci do sometimes form in various points in the medulla of a long bone, and by gradual increase in size these may finally coalesce and form a diffuse tuberculous osteomyelitis; such a condition in the larger bones is, however, quite uncommon.

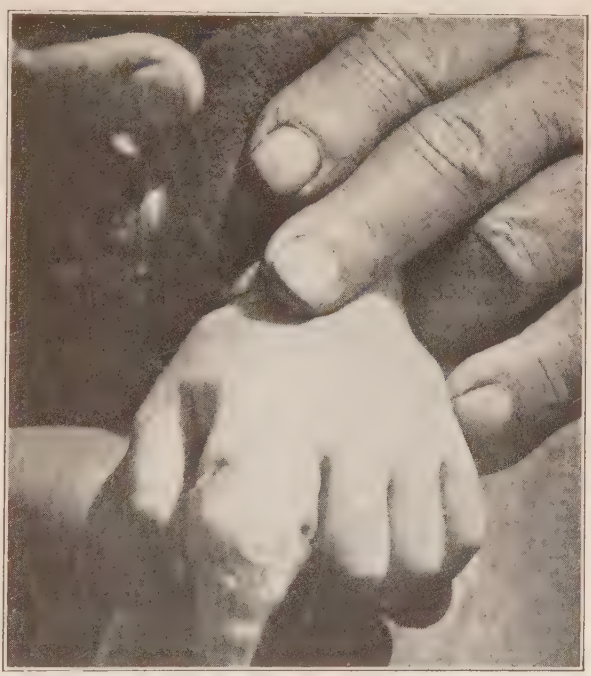


Fig. 26.—Tuberculosis of the First Phalanx of Index Finger, with Sinuses. (Spina ventosa, author's collection.)

Mode of Infection.—The infection takes place in many instances primarily through the blood in the form of an infected embolus. A circumscribed focus of tubercular granulation tissue is produced which undergoes the same changes as tubercle tissue elsewhere. A tuberculous caries of the bone, a sequestrum, or a tuberculous abscess may thus be produced. The foci may be single or multiple, and are usually of moderate size.

The process is very prone to extend into the neighboring joint or to perforate the cortical layer and infect the overlying periosteum and soft parts. In certain situations, notably in the phalanges of the fingers of children – less commonly in the shafts of the longer bones of children and adults – there occurs a tuberculous osteomyelitis which results in gradual absorption of the cortical layer of bone, while irritation of the overlying periosteum causes the production of new bone. In the fingers a spindle-shaped enlargement of the affected phalanx occurs; and in the shafts of the larger bones — notably the tibia—localized swellings are produced (Spina ventosa).

Course.—The course of bone tuberculosis is exceedingly chronic. The general health is often but slightly affected. Fever may occur from time to time, but the temperature is not greatly elevated. So long as the tubercular process remains confined to the interior of the bone the signs and symptoms are either absent or slight. Pain is not a marked symptom. Tenderness may be present on percussion over the affected area. Invasion of the periosteum is accompanied by pain, tenderness, and apparent enlargement of the bone, with edema of the overlying soft parts. Invasion of a joint is attended by the signs of joint tuberculosis to be described. Perforation of the periosteum and invasion of the overlying soft parts and skin are indicated by the formation of a cold abscess or by the presence of a tubercular ulcer or sinus. A probe introduced into such a cavity may meet with carious bone or pass directly through a perforation into the medullary cavity, or if, as often happens, the tuberculous abscess has traveled along intermuscular planes by gravity, from a distance, no diseased bone can be reached, and the diagnosis must be arrived at by other means.

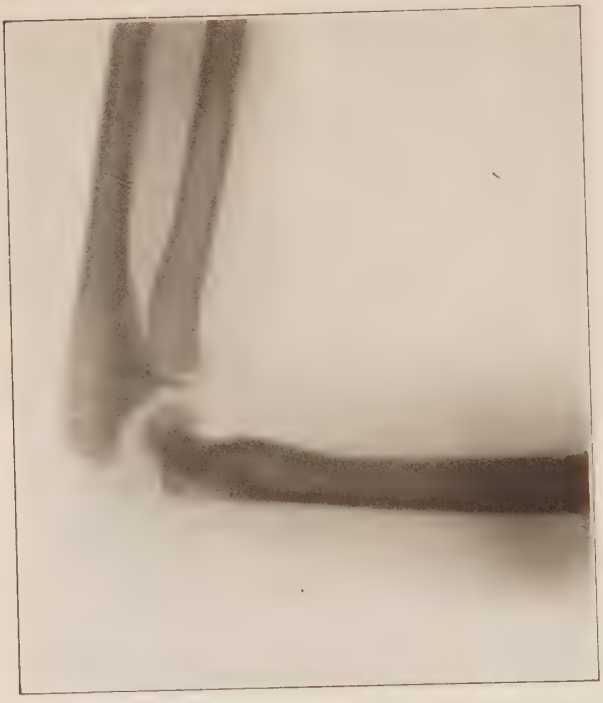


FIG. 27.—X-RAY PICTURE OF EARLY TUBERCULOSIS OF THE ELBOW IN A CHILD, SHOWING SLIGHT DESTRUCTION OF THE ANTERIOR SURFACE OF THE HUMERUS JUST ABOVE THE ELBOW JOINT. The joint had not yet become involved, there was but little limitation of motion in the elbow and scarcely any pain. The child was a patient of Dr. Chas. N. Dowd, who very kindly sent the patient to me to have an X-ray picture taken to discover if possible whether and to what extent the bone was involved. It is often possible to make a diagnosis of early tuberculosis in the epiphyses of the long bones before the associated joint disturbances are at all marked.

Diagnosis of Bone Tuberculosis.—After perforation of the overlying soft parts and the formation of a cold abscess or a sinus, diagnosis is usually quite easy. In the absence of such signs, the presence of a tender bony swelling of a chronic character, especially if near a joint, will lead to a suspicion of tuberculosis. The presence of other tubercular lesions in the lungs, lymph nodes, or elsewhere renders the diagnosis more probable. Absence of a syphilitic history, or, in doubtful cases, rebelliousness to antisyphilitic treatment is sometimes a further aid. The acute infectious processes of bone run a far more stormy course. The chronic suppurations of bone have certain distinctive features noted under the head of Acute and Chronic Suppurative Osteomyelitis and Periostitis. Further, tuberculosis of the bones of certain regions produces deformities and other signs of a very definite type; a description of these will be found in the chapters on Regional Surgery.

In certain cases an X-ray picture may show the presence of tuberculous foci in bone with great clearness, and thus furnish valuable diagnostic information. (See chapter, "The X-rays in Surgical Diagnosis.")

Tuberculosis of the Long Bones.—In reference to tuberculosis of the long bones, it is to be remembered that the *epiphyses* of long bones are the *favorite seat.* Bony enlargements and inflammations of the shafts of long bones—especially in adults—are more apt to be due to syphilis, to a new growth, or to ordinary septic processes.

TUBERCULOSIS OF JOINTS

Joint tuberculosis is most frequent in childhood and youth, but may occur at any age. The knee, the hip, the ankle, the elbow, the wrist, and the intervertebral joints are most commonly invaded. One joint is usually involved, occasionally several joints in succession. The disease is in the larger number of cases secondary to bone tuberculosis of the neighboring epiphyseal extremities. Less often the synovial membrane of the joint is the primary seat of the disease. The other joint structures rarely; the cartilage, apparently never. We may in some instances, at least, distinguish clinically between the cases primary in the bone and those beginning in the synovial membrane.

Tubercular Arthritis—Secondary to Bone Tuberculosis.—The advent of the joint trouble is slow and insidious; and the subsequent course, as a rule, exceedingly chronic, extending over months and years. Attention is often first called to the affected joint by a feeling of fatigue, slight pain or weakness in the limb after prolonged use. The child is seen to favor the part. After a time a careful examination may reveal a little tenderness over the point in the bone near the joint the seat of the tuberculous focus. At this time the joint will be found, as a rule, normal in contour and size; limitation of motion, if present at all, will be slight, and only appreciable upon careful manipulation. Slight tenderness may be complained of upon crowding the joint surfaces together.

In many cases the symptoms will be so slightly marked that medical aid will not be sought for weeks or months. The disease often shows at first distinct remissions, so that the slight weakness or lameness will cease for a time to be observed. After a time the symptoms return, and are a little more severe. It is noted that the child sleeps badly, is restless, and utters sudden cries at night. If carefully observed, it will be noted that these cries are associated with spasmodic contractions of the affected limb. Lameness or weakness becomes distinctly noticeable; the limb assumes some characteristic position, and attempts to make free passive movements are resisted and attended by pain.

Typical Case of Tuberculosis of the Knee-joint.—According to the anatomical seat of the affection the signs will, of course, vary. If, for example, the knee were the seat of the disease, examination would show complete or partial obliteration of the normal depressions upon either side of the ligamentum patellæ; and slight increase in circumference above that of the normal knee; and a little thickening of the periarticular soft parts. A tender point is often to be noted over one of the condyles of the femur or tibia. The joint is held a little flexed, and distinct limitation of passive and active motion is present. Attempts to exceed these limits are accompanied by spasmodic fixation of the joint by the muscles and by pain. The skin over the joint is normal in color, but may feel a little warmer than its fellow.

FIG. 28.—TUBERCULAR ARTHRITIS OF THE KNEE JOINT SHOWING SWELLING OF THE JOINT OF THE CHARACTERISTIC SPINDLE SHAPE. Primary focus in the internal condyle of the femur. Note the position of moderate flexion. (New York Hospital, service of Dr. P. R. Bolton.)

SIGNS OF EFFUSION INTO THE KNEE-JOINT.—There is often at this time a moderate effusion into the joint, and the sensation known as "*floating patella*" may be appreciated, although such considerable effusion is the exception rather than the rule. This sign is elicited in the following manner:

The limb is placed in the extended position with the heel supported—if the knee-joint is *flexed* no amount of fluid in the joint is sufficient to raise the patella away from the condyles of the femur—the surgeon places the thumbs and middle fingers of each hand upon either side of the ligamentum patellæ and the quadriceps tendon, one hand above the other below the patella, and makes firm steady pressure over these places, in order to force the fluid in the joint beneath the patella and cause it to lift this bone away from the condyles of the femur. The forefingers of either hand are then placed upon the patella and used to push the patella backward against the condyles. If any considerable amount of fluid exists in the joint a feeling of elastic resistance is imparted to the fingers. If the pressure by the forefingers is suddenly increased, the resistance is overcome, and the patella is felt to strike the condyles of the femur a sharp tap. Although hard to describe, the manipulation is simple, and the sensation conveyed to the fingers so characteristic as to be unmistakable. As the pressure of the fingers is relaxed, the patella is felt to rise again from the condyles.

The synovial bursa above the patella, and behind the quadriceps tendon, usually forms a part of the knee-joint, and may, if it contains fluid, form a rounded elastic swelling of considerable size beneath the quadriceps tendon. The normal depressions on either side of the tendon are obliterated. These are some of the signs of effusion into the knee-joint, and are observed whenever fluid is present in that joint.

Later Symptoms.—Even early in tubercular arthritis a blow upon the heel upward, with the knee extended, causes pain. As the disease goes on all the signs become more marked; the limb becomes more flexed, motion—active and passive—more restricted; the joint more swollen, the swelling is of rounded bulbous character. The muscles of the thigh and leg undergo partial atrophy, and thus increase in size of the joint is more noticeable. The skin of the knee is of a dead white or waxy color (tumor albus—white swelling). Palpation of the joint shows the periarticular infiltration to be of a firm character, or in some instances softer and almost boggy. Bony foci, which have reached the bone surface outside the joint, cause periosteal thickening and apparent enlargement of one or other bony condyle.

From time to time a sudden increase of all the symptoms takes place. There is acute pain in the joint, an increase of swelling, sometimes moderate fever. It may be noted here that the pain of joint tuberculosis is not entirely referred to the affected joint, but is often in part a *referred pain*. The most common example of this is to be noted in tuberculosis of the hip; here the pain, in the early stages of the disease, is referred to the inner aspect of the knee. These sudden exacerbations are sometimes caused by the invasion by the tubercular process of hitherto unaffected portions of the joint. The movements of the joint become more and more restricted. In some instances passive movements elicit crepitation, indicating the rubbing of bony articular surfaces together, denuded of their cartilages. Firm, fibrous, or, in some cases, after

years, bony ankylosis may result. The muscles become permanently shortened. In the case of the knee, flexion, and, later, external rotation become more and more marked. The tibia is dragged farther and farther backward from the condyles of the femur, and in untreated cases partial or complete dislocation results.

Fig. 29.—Tubercular Cold Abscess of the Back Secondary to Tuberculosis of a Rib. (New York Hospital collection.)

Cold Abscess. — When the tubercle tissue in the joint or in the periarticular structures softens and breaks down a tubercular abscess results, and, following the direction of least resistance, finally points over, near, or, in many instances, far away from the affected joint. Rupture of these abscesses leaves behind the characteristic tuberculous ulcer and sinus. In old cases many such abscesses may successively form, one or other may wholly or partly heal, leaving a depressed and puckered scar surrounded by dense hard scar tissue.

Mixed Infection.—Secondary invasion of these tubercular abscesses and sinuses with pus-producing organisms may change the entire picture to one of acute or chronic septicemia. As the result of bony destruction, gravity and muscular action, a series of typical deformities follow tubercular arthritis. Diagnostic features of tuberculosis of special joints will be described under Regional Surgery.

Synovial Tuberculosis.—Primary synovial tuberculosis is rare among children, and much less common among adults than the form just described. While the results in some cases are the same, the picture of the disease varies somewhat from that of the former variety. The knee is the joint most often affected, and the disease is characterized in typical cases by a sudden or gradual distention of the joint with fluid. Such fluid may be serous, sero-fibrinous, or purulent.

Serous Form of Synovial Tuberculosis.—The serous form (Hydrops tuberculosis) is characterized by a very chronic course, by absence of acute inflammatory signs. There is little or no tendency to periarticular infiltration or thickening; there is very little pain; no limitation of motion. The distention of the synovial sac causes stretching of the ligaments and a weak and wabbling joint. Genu valgum, genu recurvatum, or subluxation may occur in neglected cases; the use of the limb then becomes difficult and painful. The effusion may suddenly or slowly diminish, and even disappear, to recur after a variable interval; under such circumstances there may be much difficulty in arriving at a correct diagnosis. The existence of other tuberculous lesions, a feeble state of health, and flabby tissues will render the diagnosis of tuberculosis more probable. Aspiration of the fluid contained in the joint and the inoculation of guinea pigs may give a positive result. An exception to this picture occurs when, as sometimes happens, an acute miliary tuberculosis of the entire synovial membrane of one or more joints—most often of the knee—occurs in an individual already the subject of tuberculosis elsewhere. The onset of the joint symptoms is sudden and acute; the joint rapidly swells; there is acute pain from the sudden distention of the synovial sac; the skin is reddened and edematous; the patient has a considerable rise of temperature. After a time the acute symptoms subside, and a chronic tuberculosis of the joint results. Healing and cure is said in some cases to ensue after the subsidence of the acute symptoms.

Fig. 30.—Primary Synovial Tuberculosis of the Knee Joint. Enormous Tuberculous Hydrops. No pain. No limitation of motion. Patient a male, aged fifty-two years. (New York Hospital, service of the author.)

Fibrinous Form of Synovial Tuberculosis (*Hydrops tuberculosis fibrinosum*).—The fibrinous form is characterized by the presence in the

serous exudate of considerable quantities of fibrin. The presence of fibrin may sometimes be appreciated in the joint by palpation, a peculiar sense of soft friction being transmitted to the fingers. In many instances these cases of tuberculosis hydrops go on to develop the ordinary form of fungous arthritis.

Purulent Form of Synovial Tuberculosis (*Cold Abscess of the Joints*).—The purulent form usually occurs in adults, rarely in children. The subjects are badly nourished and suffer from other foci of tuberculosis. The *clinical signs and symptoms* do not differ materially from the serous type, except that the joint capsule is more apt to be perforated with the production of periarticular cold abscess. The effusion may occur suddenly or slowly, but without marked signs of an inflammatory character. Aspiration will reveal the presence of tuberculous pus in the joint. The lesion is usually a diffuse synovial tuberculosis; although similar abscesses occur in the tubercular arthrites secondary to tuberculosis of bone.

Diagnosis of Bone and Joint Tuberculosis.—The diagnosis is in many instances extremely easy. The presence of sinuses, the characteristic deformities, and the general appearance of a limb may suffice to enable us to recognize the condition at the first glance. This is not always the case in the early stages of the disease, and we should not be misled by a general appearance of good health in an individual the subject of chronic joint trouble. It is to be borne in mind that in bones and joints, as elsewhere, tuberculosis may occur as a purely local disease without disturbance of general nutrition among individuals who appear strong and well nourished. Persons with multiple tuberculous lesions of long standing, notably when complicated by chronic suppuration, become cachectic, and develop amyloid degeneration of the kidneys and liver, tuberculosis of the intestine, chronic diarrhea, and other conditions due in part to tuberculous disease and in part to unfavorable conditions of environment, and in these the

Fig. 31.—Tubercular Abscess of Thigh about to Rupture. (Collection of Dr. Charles McBurney.)

diagnosis is plain; these are not the cases in which we may err.

Differential Diagnosis of Bone and Joint Disease.—Tuberculosis of bones and joints must be differentiated from certain other conditions now to be considered.

Syphilis of the shafts of the long bones is generally a much more painful affection than tuberculosis. The formation of a large cold abscess, characteristic of tuberculosis, does not occur in syphilis. The syphilitic process is usually of a productive character with the formation of new bone and notable enlargement of the shaft. Upon operation tuberculous bone is usually soft and friable. Syphilitic bone is dense and often very hard. A microscopic diagnosis is often possible. In certain anatomical regions syphilitic necrosis of bone is so common and runs so typical a course, while tuberculosis is

FIG. 32.—EXTREME CONTRACTURE OF BOTH KNEE JOINTS FROM QUIESCENT TUBERCULAR ARTHRITIS. (Collection of Dr. Charles McBurney.)

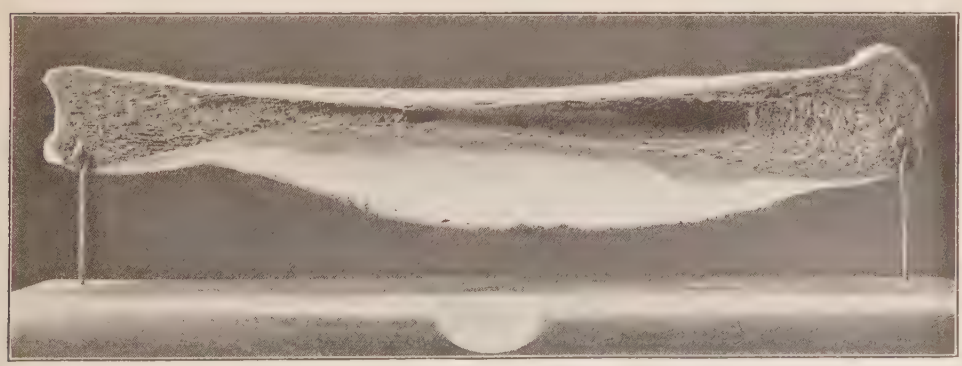


FIG. 33.—SYPHILITIC PRODUCTIVE INFLAMMATION OF THE TIBIA WITH GREAT THICKENING OF THE SHAFT. (New York Hospital Museum.)

so rare, that confusion is hardly likely to arise. This is notably true of the bones supporting the nose and the roof of the mouth. (See Regional Surgery.)

Acute osteomyelitis is a sudden, violent infectious process running an acute course, and attended by marked acute local and constitutional symptoms. It bears no likeness to tuberculosis in the chronic stage; and in the cases of osteomyelitis which are subacute or chronic the following characteristics are to be noted: Tuberculosis is located in the epiphyseal ends of the long bones—in their shafts rarely; suppurative osteomyelitis affects the shafts usually—rarely the epiphyses. The sequestra of tuberculosis are small, ragged, friable portions, usually of cancellous tissue, often lying in a cavity lined with typical tuberculous granulations. The sequestra of osteomyelitis are often in the form of long, flat, usually thin, plates of yellow, hard, worm-eaten bone. They are usually surrounded by an abundant layer of highly vascular granulation tissue and by an abundant involucrum of healthy bone of new formation.

FIG. 34. SYPHILITIC NECROSIS WITH DESTRUCTION OF THE NASAL BONES. Hereditary syphilis. (Collection of Dr. Charles McBurney.)

In the rare cases of suppurative osteomyelitis limited to small foci in the epiphyses of the long bones, and running from the start a subacute or chronic course, the distinction from tuberculosis may be impossible without operative inspection, and even microscopic examination of the diseased tissues. (See Osteomyelitis.)

The differential diagnosis between a simple relapsing or chronic articular hydrops of traumatic origin and a tubercular hydrops is not always possible without prolonged observation. Immobilization of the joint for a few weeks is usually followed by improvement in both conditions. Each recurrence of the effusion in the absence of a trauma renders the diagnosis of tuberculosis more probable. We are often justified in opening and washing out the joint if the condition has proved itself rebellious to other forms of treatment, when the character of the fluid and the appearance of the synovial membrane may suffice to render the diagnosis clear. (For tuberculous lesions of other structures, see Regional Surgery.)

DIFFERENTIAL DIAGNOSIS OF TUBERCULOSIS FROM CERTAIN OTHER DISEASES OF JOINTS

Arthritis Deformans.—Arthritis deformans occurs in elderly people or follows severe trauma—i. e., fractures into the joint, healing with deformity. The progress of the disease is slow but steady; cure with *restitutio ad integrum* is impossible. The remissions and exacerbations of tuberculosis are absent or less marked. The ends of the bones forming the joint are enlarged, often much more than ever occurs in tuberculosis, or bony absorption takes place at one point while hyperostosis is present in another. The deformities differ notably from those of tuberculosis and are characteristic. (See Arthritis Deformans of Special Joints.) Sometimes bony outgrowths can be felt along the borders of the joint or loose bodies within the synovial sac. Abscesses and sinuses do not appear, nor does caries or necrosis occur. Several joints are commonly affected.

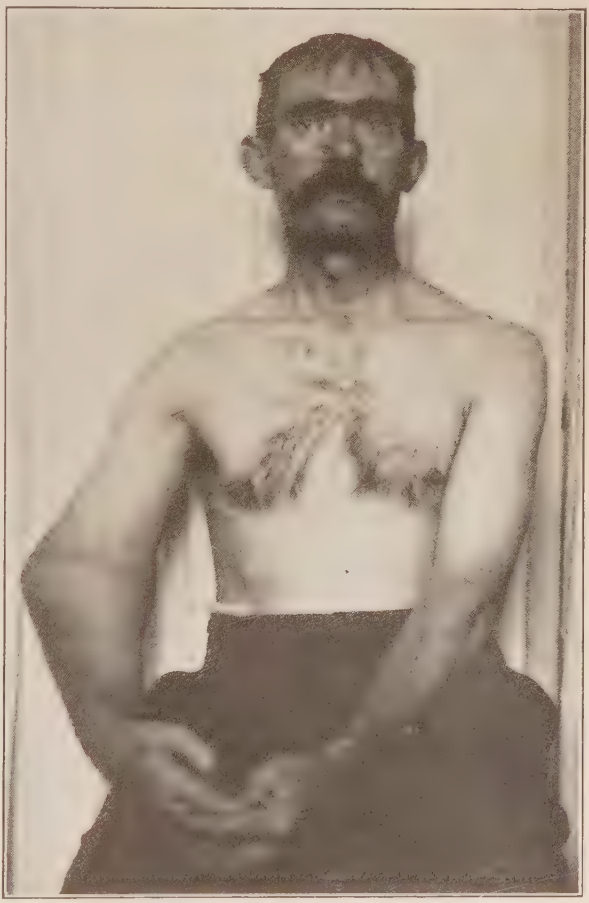


Fig. 35.—Charcot's Elbow in a Case of Tabes Dorsalis. Note the absence of atrophy of the limb so commonly seen in tuberculosis. (New York Hospital, service of Dr. L. A. Stimson.)

Hysterical Joints.—In joints not easily accessible to direct palpation the mimicry of hysteria may for a time render the exclusion of serious organic lesions difficult. The following are some of the diagnostic characters to be noted in purely neurotic joint affections: The amount of pain and tenderness complained of does not correspond with the physical signs. Tenderness is superficial or general, or is felt over an area which does not correspond to the anatomical arrangement of nerve trunks, often geometrical in form. The muscular spasm and limitation of motion or fixation of the joint disappear during narcosis. The pain does not usually interfere

with sleep. Vasomotor disturbances of the affected region are common. Hyperesthesia of the skin over the entire joint, subjective sensations of heat or cold and tingling are often present, and areas of anesthesia are sometimes to be noted. Improvement or cure often follows the use of painful or disagreeable methods of treatment—for example, the actual cautery, the wet-pack, etc. (See "Traumatic Hysteria.")

Fig. 36.—Charcot's Knee-joint. (New York Hospital, service of Dr. Frank Hartley.)

Charcot's Joint.—The disorganization of a joint in the course of tabes dorsalis bears but slight resemblance to tubercular arthritis. There is in most of these cases a history of syphilis. Other signs of tabes are present—loss of knee-jerk, the characteristic pains of tabes, trophic disturbances of the skin of the soles of the feet, the Argyll Robertson pupil, disturbances of the bladder and rectum, or some combination of these signs. The knee is the joint most often affected. There is a striking absence of pain and tenderness in the joint. There is no limitation of passive motion. The ligaments are relaxed, permitting an undue amount of lateral mobility of the bones. The joint usually contains much fluid. There is often destruction of the cartilages, complete or partial, and fibrous or bony grating on passive motion. Manipulations of this kind are painless, or but slightly painful. In fact, the most important diagnostic sign of the disease is the absence of pain in presence of the perfectly evident destructive lesion of the joint.

Traumatic Synovitis in Tabes.—A milder form of joint disturbance occurs in many cases of locomotor ataxia, notably in the knee-joint; the condition

follows trauma, a blow, a sprain, such as these patients are constantly being subjected to on account of their imperfectly coördinated movements and diminished sensibility. The joint (very often the knee) exhibits a moderate painless distention with fluid, a serous synovitis, which diminishes or disappears under appropriate treatment, but is prone to recur and to become chronic. The diagnosis is easily made from concomitant signs and symptoms. Some of the severe forms of tabetic joint disturbance run an acute course. The knee may be entirely disorganized in a few weeks. Portions of the condyles of the femur or tibia may be found loose in the joint cavity, and spontaneous fractures of the shaft of the femur or tibia may occur. While the picture does not bear any resemblance to tuberculosis, there is a certain likeness to arthritis deformans, except that the productive character of the latter is wanting, no new bone is thrown out, no cartilaginous plates are to be felt, and no ankylosis occurs.

Pyogenic infection is not very uncommon in the course of tabetic joints. The process runs a violent course under the guise of a rapidly destructive

Fig. 37.—Arthritis Deformans of the Joints of the Fingers in an Old Woman. (New York Hospital Medical Service.)

septic arthritis. The tissues react feebly or not at all. The joint becomes distended with pus; the joint capsule is soon perforated, and periarticular purulent infiltration and abscess run riot up and down the limb. The symptoms of profound septicemia coexist. The articular ends of the bones and the ligaments melt away, and total destruction of the joint is sometimes accomplished in a surprisingly short time.

Intermittent Hydrops of Joints.—A rare and obscure affection which exhibits the characters of an acute serous synovitis, most often of one or both knee-joints, occurs without apparent cause; comes on suddenly, lasts usually for three or four days, and as suddenly disappears or diminishes, only to recur after an interval which appears to be fairly constant for the given case. According to Benda, who collected fifty-six cases, the intervals between the attacks are most commonly eleven or thirteen days, sometimes nine days, sometimes four weeks. Swelling of the thigh and of the face sometimes accompanies the effusion into the joint.

I have recently observed one case. The patient was a man, aged twenty-seven years. His first attack had occurred five years before. Without apparent cause a sudden effusion took place in the right knee-joint. There was pain in the knee and swelling, but no tenderness or redness of the skin. The joint had become normal at the end of a week. Since that time he had had eleven attacks, sometimes in the right, sometimes in the left knee. The attacks have gradually diminished in frequency. They have not been influenced by any form of treatment, nor have they exhibited any definite periodicity. The observed attack was quite typical; the left knee was greatly distended with fluid, and painful. There were no signs of periarticular infiltration. There was fever—102° F.—but no constitutional depression. Pulse not affected. The effusion disappeared in four days entirely. A new effusion then appeared in the opposite knee, persisted a few days, and disappeared. The joints then appeared to be normal, and the patient withdrew himself from observation.

Fig. 38. — Arthritis Deformans of the Knees. (Collection of Dr. Charles McBurney.)

Syphilis of Joints

Syphilitic Arthralgia.—During the early months of acquired syphilis, pain of a severe character, and worse at night, is commonly felt in the joints. Such pains are also a very frequent symptom in hereditary syphilis. In the acquired form such pains more commonly precede the general eruption than follow it. The symptoms are subjective merely. Objectively, no signs of joint disturbance are to be observed. The diagnosis is to be made by the other evidences of syphilitic infection—by the disappearance of the pains as the patient comes under the influence of mercury.

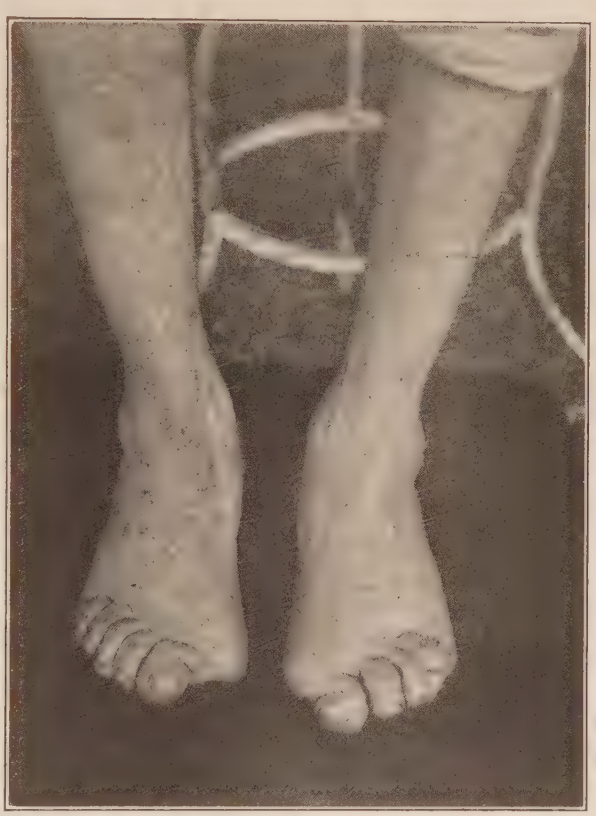


Fig. 39.—Arthritis Deformans of the Joints of the Toes. (New York Hospital, Out-Patient Department.)

Syphilitic Synovitis.—Syphilitic inflammation of the joints occurs during the early or active period of the disease as a mono- or polyarticular serous synovitis. Its appearance may be synchronous with that of the general cutaneous eruption, or occur at any time during the active period of the disease. The joints are painful, swollen; local heat may be present or not; the skin is rarely reddened. The joints may be moved, within certain limits, without increase of pain; beyond such limits motion is painful. If several joints are involved the process ends in complete resolution in all after a week or two, or one joint may recover more slowly or become the seat of a chronic synovitis. During the acute portion of the attack there is a little fever. The presence of other signs of active syphilis will usually serve to exclude acute articular rheumatism. As in all syphilitic lesions, the effect of treatment is an important aid in diagnosis.

Syphilitic Arthritis.—During the later or tertiary stage of syphilis, and in hereditary syphilis, a variety of joint disturbances may occur, due to primary gummatous infiltration of the joint structures themselves or to secondary in-

volvement of the joint from gummata of the bones. The knee and sternoclavicular joints are most often affected. The elbow, wrist, ankle, metatarsal, metacarpal, and interphalangeal joints are involved in the above order of frequency (Hartley). The lesions are, briefly, fibrous degeneration of the cartilages, papillary thickening of synovial membrane, gummata in any of the periarticular structures. The fluid in the joint is serous, or, in the event of gummata breaking down into the joint cavity, puriform or purulent. *Periostitis* and enlargement of the epiphyses, not unlike that observed in rachitis and due to periostitis or osteomyelitis of the epiphyses, is a common lesion in the hereditary syphilis of children. The disease is rarely acute, usually chronic in its course. The clinical picture closely resembles tubercular arthritis: the bulbous enlargement of the joint is the same, but the periarticular thickening is more dense and firm in syphilis. The formation of abscess and joint suppuration is very rare in syphilis. The pain of syphilis is often severe, and worse at night. Functional disability is far less marked in syphilis, and scarcely corresponds with the gravity of the organic lesion. The acute exacerbations of tuberculosis, with an accompanying fever, are wanting in syphilis. The contractures of the muscles and the resulting deformities are similar in the two diseases. The limitation of motion is less marked in syphilis than in tuberculosis, although both may be followed by complete or partial ankylosis. Other evidences of syphilis may be present—a history of infection, osteitis, and periostitis of the long bones. Syphilitic scars or ulcers should be sought for. Gummata are not infrequently present, and may be palpable as firm, insensitive nodules around the affected joint, in the soft parts, or on the bones.

Bilateral Disturbance of the Knee-joints.—In hereditary syphilis, bilateral disturbance of the knee-joint is fairly frequent. The occurrence of a sudden effusion into both knees in a young child, without much constitutional disturbance, is cause for suspicion of this disease.

"The following varieties of joint disturbance may be distinguished in hereditary syphilis (Robinson): 1. A specific epiphysitis, with or without spontaneous separation of the epiphysis. 2. Symmetrical effusions, occurring suddenly and without pain, commonly between the eighth and fifteenth year of life. 3. Osteitis, (*a*) with simple effusion, (*b*) with gummatous infiltration of the synovial membrane and effusion. 4. Primary gummatous synovitis. (See Diseases of Special Joints.)

"Interstitial keratitis is a frequent complication. Suppuration of joints is much more common in the hereditary than in the acquired form of the disease." (P. Reichel.)

Hemarthros in Hemophilia.—In persons—notably children—the subjects of hemophilia, sudden effusions of blood into one or several joints occasionally occur, without apparent cause or after slight trauma. The knee-joint is the most frequent seat. The effusion occurs suddenly, and without pain. The joint is found to be distended with fluid. The occurrence, after a time, of

ecchymotic discoloration of the skin, if no injury has occurred, and a family or personal history of bleeding, may lead to a correct diagnosis. If seen at a later stage, a differential diagnosis from tuberculosis, gout, or rheumatism may be very difficult. The blood may be entirely absorbed with perfect restoration of function, or the clot may be replaced by organized tissue and a greater or less degree of limitation of motion may remain, or even ankylosis and contracture of the muscles, with a high grade of deformity. Absence of abscess or fistulæ, the occurrence of effusions in several joints in succession, with absorption after a time and return to a normal state, and a notable anemia, constitute some of the diagnostic data of this rather rare condition.

Gonorrheal Rheumatism.—Metastatic inflammations of joints occur in from two to three per cent of the cases of gonorrhea. The condition is sometimes due to constitutional invasion and localization in the synovial membranes of joints, tendons, and bursæ by the gonococcus alone, sometimes apparently to mixed infection, with pyogenic bacteria in addition. In the joint exudate the gonococcus has been demonstrated morphologically in a number of cases, usually during the early days of the joint inflammation. The disease is more common in men than in women. It occurs most commonly during the three months following infection, but rarely before the end of the first week. The disease affects the knee most often, then the ankle, the fingers and toes, wrist, shoulder, etc. Several joints may be involved successively, and one attack predisposes to another. More than half the cases are polyarticular. The disease occurs in mild and severe forms, according to the intensity of the infection. The exudate may be serous, sero-fibrinous, sero-purulent, or in rare cases purulent. Upon the onset of the joint symptoms the urethral discharge, if such existed, usually diminishes or ceases. In men, the disease occurring as it does in the course of gonorrhea is easily recognized; in women it is not always so. At the onset of the acute form of the disease there is often *malaise*, moderate fever—99.5° to 102° F.—pain in one or several joints, and, finally, pain and swelling in one joint, usually the knee. The intensity of the symptoms, local and general, vary with the severity of the infection. In the milder serous and sero-fibrinous forms the knee will be swollen, tender, more or less painful, red, and hot, and the signs of fluid in the joint will be distinct. These symptoms last for a few days or a fortnight; in favorable cases they entirely disappear in three or four weeks. Relapses are common, and may lead to a chronic synovitis, a synovitis with papillary thickening of the synovial membrane, to intractable fibrous ankylosis, or even to bony ankylosis, or a condition resembling arthritis deformans. The patella is very apt in these chronic cases to become adherent to the condyles of the femur. In the purulent and sero-purulent cases the symptoms will be more severe. The pain, heat, redness, and swelling of the joint will be more marked; there will be more edema and infiltration of the periarticular structures; there may be severe throbbing pain in the joint; rarely, actual suppuration takes place, the capsule of the joint is perforated, periarticular abscesses form. Some of these cases develop pyemia; the most

favorable outcome is ankylosis. In men, the presence of a urethral discharge or of a posterior urethritis, with shreds or purulent urine, will suggest the true cause of the joint affection. In women, the signs of recent gonorrheal infection are not always plain. In cases of doubt, the urethra, the Bartholinian ducts, and the cervix uteri should be examined for a gonococcus-bearing discharge.

Diagnosis of Acute Exudative Lesions of Joints.—As the result of subcutaneous and open wounds, as complications in the course of a great number of general diseases, most of them of an infectious character, and in the regular course of special diseases of the joints themselves, an exudative inflammation takes place in the joint structures, and the synovial cavity becomes more or less distended with fluid. Such fluid may consist of serum, of serum and fibrin, of serum containing a moderate amount of pus, or, finally, of pus. We speak of a serous synovitis or arthritis, a sero-fibrinous synovitis or arthritis, a sero-purulent synovitis (the catarrhal synovitis of von Volkmann), or a purulent arthritis, if the exudate consists of true pus.

Use of the Aspirating Needle.—In accessible joints, when in doubt as to the character of the fluid, we may introduce an aspirating needle into the joint cavity, under proper precautions, and withdraw some of the fluid for examination. It may be well to remark in passing, that clotted blood cannot be made to pass through a needle, and that partly clotted blood passes with difficulty. The exudate of serous synovitis is a pale, straw-colored fluid, usually slightly turbid from small flocculi of fibrin. Under the microscope, moderate numbers of leucocytes may be seen singly or in groups, with a greater or less number of red blood cells, if the synovitis was of traumatic origin. A sero-fibrinous exudate contains masses and flocculi of fibrin in varying amounts. The sero-purulent exudate is distinctly cloudy, and under the microscope is seen to consist to considerable extent of white cells. The purulent exudates exhibit the ordinary characters of pus.

Synovites.—Causation.—Subcutaneous injuries of joints—contusions, distortions, and the like—are followed by a serous synovitis. Open wounds of joints, if noninfected, may be followed by a similar process. Mono- and poly-articular acute rheumatism and gout are accompanied by a synovitis of this type. Serous synovites are not uncommon in the course of active syphilis. The acute infectious diseases—measles, scarlet fever, small-pox, gonorrhea, diphtheria, erysipelas, typhoid fever—are often complicated by synovites, sometimes serous, sometimes sero-purulent or purulent in character. Acute suppurative processes in the neighborhood of joints may extend to and infect the joints themselves—acute osteomyelitis and periostitis, for example, as well as infected wounds and abscesses of the soft parts overlying the joint. Metastatic suppuration in joints is common in pyemia (see Pyemia). The diagnosis of some of these forms of joint inflammation merit separate attention, and will be found under appropriate headings. Some of the characters of the different types of inflammation may, however, be spoken of here.

The acute serous synovites following injury are easy to recognize. The

injury is usually rather severe: a violent wrench of the joint, such that one or more ligaments are stretched or torn, a severe contusion, a partial or complete dislocation, or a fracture in the neighborhood of the joint is the usual cause. The effusion occurs at once, or within a few hours. The joint becomes swollen, and in suitable situations fluctuation in the joint is appreciable. Pain may be slight, moderate, or severe, according to the degree of tension of the capsule caused by the effusion. The joint will feel weak, limitation of motion will be more or less marked, and passive motion, carried beyond a certain degree, will be more or less painful. The skin will usually be normal in color, and there will be little, if any, local heat. Fever is absent, or quite moderate—99.5° to 101° F. Under rest and fixation, the effusion, etc., will begin to subside in a few days. The formation of a hematoma in a joint cavity (hemarthros) may be suspected if the effusion fails to diminish rapidly after a few days of rest, and if, without evidence of fracture or external contusion, ecchymotic spots make their appearance near the joint. Further, the soft friction of fibrinous masses may sometimes be felt on manipulation. The introduction of an aspirating needle will answer the question positively. In the presence of an *open wound* of a joint the escape from the wound of a clear, yellowish or blood-stained, sticky fluid is sufficient evidence that the joint is wounded, and a change in the character of this fluid to sero-purulent or purulent discharge indicates that the joint cavity is infected. In accidental wounds of joints it is of the greatest consequence to recognize such infection at the earliest possible moment. The constitutional symptoms of sepsis may come on suddenly and violently before the local evidences of joint infection are marked; but, on the other hand, the process is very often insidious, and constitutional symptoms may be slight for many days, while the joint structures are becoming too profoundly affected to save by conservative local treatment.

Pyogenic Infection of Joints.—Course of the Disease.—The ordinary course of purulent wound infection of the larger joints is as follows: The joint becomes intensely painful; there is fever, often with a sudden marked rise of temperature; in some instances a chill. The joint rapidly swells, the skin over the joint is edematous, often hot and red; the whole limb is often swollen. The function of the joint is abolished and the slightest movement causes exquisite suffering. The exudate in the joint may or may not give rise to fluctuation; it is frequently small in amount at first, and may be masked by the swelling. The joint is held in such a position as to relax, as far as may be, the tension of its capsule, usually in a position of partial flexion. The further course depends upon the character of the infection, and to a great extent upon the treatment. Cultures made from the purulent exudate often furnish useful data upon which to form an opinion of the gravity of the situation. The presence of the yellow staphylococcus or of Streptococcus pyogenes indicates a grave form of infection. In bad cases the symptoms become those of septicemia or pyemia. All the joint structures become involved in the suppurative process (panarthritis). The cartilages are softened and separated

from the bones, the ligaments are softened and relaxed, the joint capsule is perforated, and abscesses form outside the joint and burrow up and down the limb in the intermuscular planes. Subluxation may occur. Healing, with limitation of motion or ankylosis, are the most favorable results to be expected in these cases. (See Regional Surgery.)

Metastatic Synovites.—The metastatic synovites complicating the acute infectious diseases are sometimes confined to one joint; more often they are polyarticular. They are frequently purulent in character, and are in many instances part of a secondary pyemia. Sometimes the exudate is serous or sero-purulent, and the course of the disease more like that of an acute polyarticular rheumatism. Even in the purulent forms the local signs are much less acute than is the case when a joint becomes infected through an open wound. They may be but slightly painful (see Pyemia). In all acute synovites, if we except rheumatism and gout, the development of fever and other constitutional symptoms leads to the suspicion that the joint inflammation is of a sero-purulent or purulent character.

Catarrhal Synovitis.—The so-called catarrhal form of synovitis occurs as a sero-purulent joint inflammation in children. The disease is accompanied by moderate constitutional disturbance. Fever is present, but is not high. The local signs are those of an acute synovitis with pain, swelling, and limitation of motion and function; but the process does not usually end in true suppuration, nor are the inflamed joints destroyed. Recovery is possible even without operation. The cause of the condition is obscure in a certain proportion of cases.

Gout.—Gout occurs as an acute synovitis, notably in the metatarso-phalangeal joint of the great toe and in the finger-joints. It is a disease of middle and later life; is associated with an excess of uric acid in the blood. Is characterized by a tendency to recurrent attacks, and by the deposit in the periarticular soft parts of crystals of urates, sometimes forming considerable masses producing notable deformities and disturbance of function in the affected joints: such gouty tophi, as they are called, may attain a considerable size. An acute attack of gout comes on quite suddenly, with great pain in the affected toe-joint. The joint swells; the skin is reddened and exquisitely tender; motion is very painful. The attack subsides, with or without treatment, after two to four to eight days or more. The situation—absence of trauma, often a history of alcoholic indulgence, and of recurrences—together with the local signs, are sufficient to establish the diagnosis. Gouty tophi often form in the border of the external ear as well as in the vicinity of joints.

Ankylosis.—When, as the result of injury or disease, a joint becomes stiff and immovable, the condition is known as ankylosis. When the immobility is absolute and dependent upon changes in the articular surfaces, we speak of a true ankylosis. When the immobility is largely due to muscular contraction such as is common in inflammations of joints and in cases of hysteria, and is completely or partly overcome under anesthesia, we speak of a false ankylosis.

When, along with more or less complete immobility, the joint is flexed at an angle and rigidly held by permanently shortened muscles, we speak of the condition as a contracture. Contractures, ankyloses, and subluxations are often found together in diseased joints. While in most instances the presence of ankylosis is readily appreciated by testing the mobility of the joint, it is usually desirable to know the cause and character of the limitation of motion for therapeutic and prognostic reasons. Aside from the history of the case, we may call to our aid inspection and palpation of the part, with and without general anesthesia, and the use of the X-rays.

Etiology of Ankylosis.—Some of the *causes* of limitation of motion in the joints are the following:

Injuries and diseases of the soft parts in the neighborhood of the joint other than the joint structures themselves, such as produce cicatricial contraction of the skin, fasciæ, muscles, tendons, tendon sheaths. Prolonged fixation of a joint in a flexed position, whether by design or neglect, in the treatment of fractures and other conditions; limitation of motion in these cases is rarely absolute; the joint can usually be moved to some extent, often freely in one direction while motion is limited or impossible in another. The history of the case usually aids greatly in the diagnosis. The presence of extensive scars following burns or other injuries with loss of substance is a self-evident causative factor. Inflammations of the muscles, tendons, and tendon sheaths, whether suppurative, tubercular, or other, often leave scars; the fixation of the tendons and muscles can usually be recognized on attempting to move the limb. Under anesthesia the immobility persists to a greater or less extent, but the elements of pain and muscular spasm are eliminated, and the actual degree of ankylosis is easier to appreciate.

Ankyloses due to injury and disease of the joint structures themselves. Fractures through a joint, with displacement or with the formation of new bone, may mechanically interfere with the movements of the joint; such ankyloses are very easy to recognize. After healing of the fracture the movements of the joint are sharply limited in certain directions. The mechanical obstacles to motion are best learned by a series of X-ray pictures of the joint; by this means they can, as a rule, be very accurately determined. A moderate degree of limitation of motion usually follows dislocations after reduction. The synovial membrane forms adhesions to itself or to the bone, such that for some weeks motion in the joint is limited and attempts at further motion are painful. With use, the limitation of motion slowly passes away. If the patient is timid, it is sometimes necessary to make passive motions of the joint under anesthesia and break up the adhesions.

Acute or chronic inflammations of the joints of all kinds may be followed by cicatricial contraction of the synovial membrane, the joint capsule, and ligaments, such that the normal movements of the joint are no longer possible. The history of the disease, the presence of limited motion, and a normal X-ray picture of the bones renders the diagnosis simple. It is to be borne in mind

that fibrous or cartilaginous union between joint surface is readily distinguished from bony union by a good X-ray picture. In cases of fibrous or cartilaginous union, the bones appear separated by a distinct interval. If care be taken to place the tube in proper relation to the limb, or, better still, by taking stereoscopic pictures, when bony union is present the continuity of bony structure is perfectly evident upon inspecting the X-ray negatives. The longer the inflammatory process has existed and the more severe its character the more the likelihood that firm ankylosis will occur. Such ankylosis may be at first fibrous, later cartilaginous, and finally bony. In bony ankylosis, passive efforts to bend the joint do not cause muscular spasm of the limb. In other forms, pain or the fear of pain causes the muscles of the limb to contract powerfully.

It is well to remember that violent efforts to break up a fibrous ankylosis caused by an antecedent inflammation of the joint structures has often produced a violent reaction, and no improvement in the condition of the joint. This is especially true of cases of ankylosis following suppurative, tubercular, and gonorrheal inflammation of joints. It is also quite possible to produce a fracture in such cases, notably when the bones are atrophied from disuse of the limb. The deformities of the articular ends of bones accompanying arthritis deformans, trophic lesions of joints (tabetic arthritis, syringomyelia), and some tuberculous lesions—such that the bones, by the formation of bony outgrowths or by bony absorption, no longer fit, and therefore are incapable of gliding smoothly over one another—can be appreciated by palpation and manipulation of the joint and by X-ray pictures. The history of these cases usually renders the diagnosis simple. In certain joints—notably the hip- and the shoulder-joint—it is necessary, when testing the degree of mobility in the joint, to bear in mind the mobility of the lumbar spine and of the scapula, respectively. (See Regional Surgery. For the diagnosis of the congenital deformities and acquired contractures of special joints, see Regional Surgery.)

CHAPTER V

DISEASES OF BONES

ACUTE OSTEOMYELITIS

Acute suppurative inflammation of the medulla and periosteum of the bones occurs as the result of infection with one or other of the forms of pus-producing bacteria, most often the Staphylococcus pyogenes aureus, sometimes other forms of pyogenic staphylococci, and occasionally Streptococcus pyogenes. Mixed infections are also observed. The disease may originate without apparent cause. In many cases infection takes place through the blood from some small suppurative lesion of the skin, an acne pustule, a furuncle, or a small infected wound. The mucous membrane of the mouth and throat, and notably the tonsils, are not infrequent portals of entry. Local trauma, often of slight degree, seems, by producing a place of diminished resistance, to determine the *locale* of the bone infection. Fatigue and exposure to cold and wet appear sometimes to act as exciting causes. Osteomyelitis is often secondary to the acute exanthemata, to diphtheria, and to typhoid fever. The disease occurs most frequently in males (4 to 1) between the ages of eight and seventeen years. It is less common among infants, and is rare as a primary disease after the bones have attained their growth.

Osteomyelitis, as the result of direct infection of compound fractures and of wounds laying bare the bones, may occur at any age. In the spontaneous form of the disease the shafts of the long bones are most often involved. According to statistics of 440 cases compiled by Haage from v. Bruns's clinic, the disease affected the femur in 38.5 per cent; the tibia, 42.16 per cent; the fibula, 3.01 per cent; the humerus, 11 per cent; radius, 5.1 per cent; ulna, 3.4 per cent. One or several bones may be involved simultaneously or successively. The ends of the shafts of the long bones are the sites of predilection for the beginning of the process. The disease may run an acute or chronic course. In the most severe cases of the acute variety the clinical picture is that of a profound septic intoxication, and death may occur in a few days before the local signs are at all marked. The disease may be ushered in by a chill, with a rapid rise of temperature to 104° or more, and a corresponding acceleration of pulse rate. Prostration is profound, and cerebral symptoms, headache, delirium, stupor, and coma occur and succeed one another so rapidly

that the characteristic local symptoms may entirely escape notice. There is often a septic diarrhea. The diagnosis in these most violent cases is often not made nor even suspected during life.

Local Symptoms.—In the ordinary acute cases the local signs and symptoms are well marked and characteristic. They will be considered separately.

Pain.—One of the prominent symptoms of the disease is pain of an intense and excruciating character referred to the affected limb. The pain may be most intense over the focus in the bone or referred to the entire bone or to a neighboring joint—for example, in osteomyelitis of the femur the pain is often most intense in the knee. The pain is worse at night and when the fever is highest. It is described as tearing, boring, or throbbing in character, and is of horrible severity. When the pus within the medullary cavity has perforated the cortical layer and spread itself beneath the periosteum or in the soft parts of the limb the pain subsides or disappears. When a new focus of infection occurs in a distant bone a new area of pain is felt, and furnishes a reliable indication of the presence of pus.

Tenderness.—Tenderness along surface of the infected bone is present as soon as the overlying periosteum becomes irritated and inflamed, and appears early in the disease. The whole length of the bone or only a portion of it may be tender, but the greatest tenderness will be noted over the inflammatory focus, and this symptom affords a valuable guide for operative interference. (Senn.)

Swelling.—During the first few days the bone may be but little swollen; later, usually at the end of a week, secondary periostitis causes a dense, hard swelling of the bone. Thrombosis of the deeper veins is regularly present, and edema of the limb results with marked and extensive swelling, often involving the entire limb. When the soft parts become involved in the suppurative process a brawny infiltration is added with burrowing of pus along the bone and the intermuscular planes. The origin of trouble in the interior of the bone may thus be lost sight of.

Dilatation of Veins.—The superficial veins of the limb are notably dilated, and constitute, after the first few days, a diagnostic sign of importance.

Redness.—Not until burrowing pus is near the surface does the skin become red, and such redness is purple, blue, or dusky-reddish brown, and circumscribed. Earlier the skin has a pale or normal color, and is often shiny from swelling and tension.

Loss of Function.—Loss of function in a limb the seat of acute osteomyelitis is absolute; the patient is entirely unable to move or use it in any way; *this symptom is invariable and characteristic.*

Spontaneous Fracture.—If the entire circumference of the shaft of the bone becomes separated as a sequestrum before sufficient new bone has been formed around it to afford strength to the limb a fracture may occur from slight degrees of violence, or even from moving the limb during a dressing.

This accident it not common. It does not occur until the disease has lasted a long time, and is therefore of no early diagnostic importance.

Separation of the Epiphysis.—If the epiphyseal cartilage becomes involved in the suppurative process, it is disintegrated, and the epiphysis and shaft of the bone become detached, simulating a fracture; such separation is of prognostic importance. The epiphyseal cartilage being destroyed, the subsequent growth of the bone may be seriously interfered with, and the limb may remain shorter than its fellow, if further growth of the normal limb occurs. In some cases the lesion is near, but does not involve the cartilage; this sometimes results in an irritative overgrowth of the affected bone, which grows larger than its fellow. (See Osteomyelitis of the Tibia.)

Synovitis.—An effusion into the neighboring joint is a regular accompaniment of osteomyelitis. It occurs as a serous inflammation as the result of circulatory disturbances, and is to be recognized by the signs elsewhere described. In a certain proportion of cases as a result of extension of the purulent infection. Purulent synovitis of a septic character arises as a serious complication, and is to be recognized by the local signs referable to the joint (see Joints) and by an increased gravity in the general symptoms of septicemia.

General Symptoms.—The constitutional symptoms of acute osteomyelitis are those of septic intoxication or acute or chronic septicemia or pyemia, according to the extent and intensity of the infection and the practicability and promptness of intelligent surgical treatment. As noted, the gravest forms of the disease are characterized by the sudden onset of an overwhelming septic intoxication. The less violent forms exhibit every gradation of septic fever. The temperature is of the continuous remittent type, usually higher in the evening. The remissions are less marked than is the rule in typhoid fever. The occurrence of a new focus of infection is accompanied by an increased elevation of the temperature curve. The pulse is increased in rapidity throughout, and is perhaps a better index of the gravity of the case than is the body temperature. In the severe cases the tongue is dry and coated; the lips and teeth coated with sordes. Confusion with meningitis may arise when the early occurrence of cerebral symptoms, a typhoid state, muttering delirium and stupor, absence of local signs of suppuration during the early days of the disease, fail to attract the attention of the surgeon to the bony lesion.

Leucocytosis.—Leucocytosis, with a relative increase in polymorpho-nuclear leucocytes, is a regular accompaniment of osteomyelitis, and may give the clew to the diagnosis in doubtful cases.

The following history illustrates the course of a case of acute osteomyelitis of the tibia ending fatally on the fifth day after the onset of acute symptoms:

A boy, aged seven years, received a blow with a stick over the upper part of the left shin bone twelve days before coming under observation. A trifling amount of pain and soreness followed the injury, but soon passed away. Ten days after

the injury, he began to suffer severe pain in the left leg. The onset of the pain was followed by a chill, vomiting, prostration, and fever. He came under observation two days later. At this time he looked very ill. His face was flushed; his tongue dry and covered with a brown coating; his lips dry and fissured. He was restless and at times delirious. There was slight general rigidity of the muscles. Heart, lungs, and abdomen negative. Temperature, 101.2° F.; respiration, 28; pulse, 132. The left leg was much swollen, notably in the upper third. The skin was white, shiny, and felt hot to the touch. There was great tenderness over the upper third of the tibia. No evidence of fluid in knee-joint, passive movements of joint painful but not restricted. The superficial veins of the leg were visibly dilated. Hemoglobin, seventy per cent. Leucocytosis of 29,800. Polynuclear cells, relative increase ninety per cent. Operation the following day. Incision over upper third of tibia. Medullary cavity opened with mallet and gouge. Considerable pus evacuated, medulla extensively involved in suppurative process. Curettage and disinfection. Needle introduced into knee-joint withdrew clear fluid. Cultures from medulla of tibia and from fluid in knee developed pure cultures of Staphylococcus pyogenes aureus. No improvement in the septic symptoms followed the operation. The temperature continued elevated. The pulse gradually increased in frequency and became weaker and more compressible. Delirium became constant and was followed by stupor. Involuntary evacuation of urine and feces. Leucocytosis on day after operation, 39,000. Death forty-eight hours after operation. Ante-mortem rise of temperature to 106.2° F.

Differential Diagnosis.—The diseases with which osteomyelitis is often confounded are: Typhoid fever, acute articular rheumatism, meningitis, phlegmonous inflammation of the soft parts, periostitis.

Typhoid Fever.—The presence of inflammatory leucocytosis usually of marked character in osteomyelitis, and its absence in typhoid, constitute an important means of differentiation. Careful search for tender points or localized enlargements of bone should be made. The regular occurrence of diarrhea and abdominal pain and tenderness in the early days of typhoid are less common in osteomyelitis, although some cases of osteomyelitis are preceded by diarrhea and bronchitis. Widal's reaction, although valuable in the second week of typhoid, cannot be relied upon in the early days of the disease as a means of excluding suppurative processes. The onset of typhoid fever is rarely so sudden as is the case in osteomyelitis, the regular prodromata of the disease are rarely entirely absent, and repeated chilly sensations are the rule rather than the sudden violent chill which commonly ushers in osteomyelitis.

Acute Articular Rheumatism.—Acute rheumatism usually affects more than one joint. The pain and swelling are limited to the vicinity of the inflamed joints and are not diffuse as in osteomyelitis. Moreover, joint complications do not occur in osteomyelitis until the disease has lasted for some days, usually for ten days, two weeks, or more. The general symptoms are much more severe in bad cases of osteomyelitis than in rheumatism.

Phlegmonous Inflammation —Phlegmonous Erysipelas.—While ordinary erysipelas bears no resemblance to osteomyelitis, since the characteristic

dermatitis of erysipelas is always easy to recognize, and has very definite characteristics of its own, it might well happen that in the presence of extensive burrowing suppuration in the soft parts after the bone abscess has perforated the cortex, the bone lesion might be overshadowed and escape notice. Incisions for drainage and relief of tension would, if an atrium be discovered in the bone, render the origin of the trouble clear. If no atrium is found, the periosteum will be thickened, velvety, and easily stripped from the bone; blood-stained pus will usually be found beneath the periosteum; the cortical layer will appear dead white or yellow. In any case of doubt, a small opening may be made through the corticalis with a gouge or trephine and the medullary cavity exposed.

SUBACUTE OSTEOMYELITIS

While among children spontaneous osteomyelitis of the shafts of the long bones usually runs a very acute course, cases occur among adults of a subacute character from the start, although the lesions may be very extensive and multiple. The following history of a case in my service at the New York Hospital will serve to illustrate this rather uncommon type of the disease:

M. P., married, aged forty years, had a miscarriage at two months, twenty-six days before admission, followed by general malaise and general pains. Twelve days ago a sharp chill, fever, prostration, and pain in the right upper arm, several days later moderate swelling of the limb. The general and local symptoms have grown worse up to the present time. On admission, patient rather poorly nourished and pale. Temperature, 103.2° F.; respiration, 32; pulse, 128. Leucocytosis, 27,500. Polymorpho-nuclear cells, eighty-five per cent. Lymphocytes, fifteen per cent. Hb. thirty-seven per cent. Right arm swollen, but not very painful. Marked tenderness over upper third of right humerus. This portion of the bone feels thicker than normal; indistinct fluctuation felt beneath the deltoid. Operation August 11th. Incision opened an abscess beneath the deltoid containing several ounces of evil-smelling, greenish pus. Periosteum of humerus raised from upper third of bone by a purulent collection surrounding the shaft; further exploration showed the periosteum everywhere thickened, velvety, and loosened. The entire shaft appears white and pale yellowish-green. With a gouge and mallet the medullary cavity was opened from end to end and found filled with stinking, green pus. Continued fever of a remittent type, seldom higher than 102° F., followed the operation. The wound remained fairly clean and the bone was gradually partly covered by granulations. September 9th, a chill. Temperature rose a little higher during the following days. The leucocyte count which had fallen after the operation rose again. Pain was complained of in the left humerus and right femur, but was not very severe. Lower third of femur and upper third of humerus became tender and felt thickened. Operation, September 15th. Diffuse purulent osteomyelitis of both femur and humerus, similar to that found at the first operation and a similar operation. Cultures of the pus from the right humerus had been negative. Cultures from the femur showed a spore-bearing rod-shaped bacillus, not identified. Gradual improvement in general condition followed. The extensive wounds granu-

lated. The patient went home on October 28th at her own request, with bare bone at the bottom of all the granulating wounds. She finally recovered completely without necrosis of bone.

THE SUBSEQUENT HISTORY

The subsequent history of those cases of osteomyelitis which survive, whether operated on or not, varies. In the most favorable cases early operation may be followed by rapid subsidence of the septic symptoms. The periosteum reapplies itself to the bone, and the wound slowly fills in and heals. Usually the vitality of some portion of the shaft is not restored. The periosteum fails to cover it entirely. The dead bone is slowly separated from the living by the formation of granulation tissue at the line of junction. Such a *sequestrum* may be a small superficial scale, or may consist of the entire thickness of the shaft for a variable length up to the entire diaphysis. The periosteum forms a new layer of bone more or less completely surrounding the sequestrum. This *involucrum* of new bone is penetrated here and there by cloacæ, through which pus is discharged in greater or less quantity as long as the sequestrum is present. The time necessary for the separation of the dead fragment varies from weeks to many months. Under unfavorable general and local conditions these patients may die of chronic sepsis with amyloid degeneration of the liver, spleen, kidneys, etc. As long as the patient's general condition remains fairly good, it is customary to wait for the separation of the sequestrum before removing it by operation.

Fig. 40.—Circumscribed Chronic Osteomyelitis of the Tibia, Showing Sinus Leading to Dead Bone. (Service of Dr. F. W. Murray.)

The recognition of the presence of dead bone is usually very simple. There will be a typical history of an acute attack of osteomyelitis, an infected compound fracture, or some equally characteristic event. There will be the presence of one or more sinuses from which pus is discharged. Quite often the greenish-yellow or ivory-white sequestrum will be visible at the bottom of

an open wound, or can readily be felt with the finger or probe. The question whether or not the sequestrum is separated from the living bone will not always be easy to answer. In some cases it may be moved with the finger, a probe, or in the grasp of an artery forceps, or pried up a little with a periosteum elevator; in other cases it may be so deeply placed, or so firmly inclosed by the involucrum of new bone, or be of such a shape, that efforts to detect its mobility may fail. If more than six months have elapsed since the original attack, and if the sinuses leading to the sequestrum are lined with healthy granulations, it may generally be assumed that it is loose. Sometimes the surgeon will have to be guided by the length of time which has elapsed since the original infection occurred, or will, in the presence of general septic symptoms demanding operative relief, discover only during the operation whether the sequestrum has separated. The X-rays are a valuable aid.

FIG. 41.—X-RAY OF CASE SHOWN IN FIG. 40, SHOWING THICKENING OF SHAFT OF THE BONE FROM CHRONIC INFLAMMATION AND CAVITY IN THE SHAFT CONTAINING A SMALL SEQUESTRUM.

PERIOSTITIS ALBUMINOSA AND SCLEROSING OSTEOMYELITIS

Two rare forms of infectious bone inflammation may be mentioned possessing the peculiarity that, although caused by pyogenic germs, they do not end in suppuration. They are the so-called periostitis albuminosa and the sclerosing osteomyelitis without the formation of pus.

Periostitis Albuminosa.—This disease begins as an acute process, with pain, fever, tenderness, and swelling of the extremity, leads finally to the formation of a sequestrum, but the process may extend over a period of months, and the subperiosteal exudate consists not of pus, but of a peculiar albuminous mucoid material. I operated upon one such case in the Roosevelt Hospital some years ago. The patient was a man; the disease had existed for two months when he came under observation. The lower half of the right tibia was notably enlarged, tender, and painful; there was no fever. Upon operation the periosteum was much thickened and raised from the bone over an area six inches long by a cloudy and sticky albuminous exudate, nonpurulent. The surface of the shaft in front was necrotic for a distance corresponding to the loss of continuity with the periosteum, but was not separated. The dead bone was chiseled away. Recovery without further necrosis and without suppuration followed. After the acute onset the inflammation is prone to subside into a subacute or chronic process. The perforation of the periosteum overlying the inflamed bone may be delayed for many weeks.

Sclerosing Osteomyelitis.—In this form of the disease the onset is acute, and is attended by the ordinary signs and symptoms of acute inflammation of bone, including periosteal thickening and infiltration of the overlying soft parts. The process does not, however, end in suppuration; the acute symptoms subside, leaving behind a permanent thickening of bone. In some of these cases continuous or recurring attacks of pain may be felt in the sclerotic bone extending over a period of years. The patient's general health may be seriously interfered with from continued suffering. Upon operating on these cases we may find no lesion except the thickened, dense, ivorylike bone; in other cases there may be found in the midst of the indurated bone a minute abscess cavity containing a very small sequestrum; such abscesses may remain for many years, causing no symptoms except pain. It will not always be easy to differentiate these cases from syphilis. The diagnosis will depend upon a history of an acute febrile attack and of acute local symptoms at the original onset of the disease, absence of a syphilitic history, and of other signs of syphilis, want of improvement following the use of mercury and iodid of potash, the presence of, or history of, acute osteomyelitis in other bones.

PERIOSTITIS

It is seldom that we are able to recognize a primary inflammation of the periosteum apart from inflammation of the overlying soft parts, on the one hand, or involvement of the underlying bone, on the other. Syphilis furnishes more examples of a pure periostitis than other conditions, as elsewhere described. Tuberculous periostitis is probably nearly always a secondary process. Acute suppurative periostitis occurs commonly enough as a complication of infected wounds of the extremities and the scalp when the periosteum is incised or torn; further, in combination with infection of the soft parts and bone sub-

stance in compound fractures, and in infected amputation stumps, and, as already described, in acute osteomyelitis. Infectious processes of the fingers (panaritium bone-felon) are often complicated by secondary involvement of the periosteum of the phalanges; the phalanx is infected, completely cut off from its blood supply, dies, and may come away or be extracted as a sequestrum. In all these conditions the periostitis forms but a part of the lesion, and requires no separate description. A common symptom-complex in all cases of periostitis consists of localized pain and tenderness, periosteal thickening, apparent, or later, real enlargement of the bone. In suppurative conditions, followed by the formation of a subperiosteal abscess, often by loss of bone substance; in nonsuppurative conditions, by temporary or permanent bone enlargement.

Periostitis, the Result of Contusion of the Bone.—The metacarpal bones and the phalanges of the fingers, the tibia, the os calcis, and less commonly other superficial bones, may be the seat of an acute, subacute, or chronic inflammation of the periosteum, nonsuppurative in character, and characterized by localized pain and tenderness, by palpable thickening of the periosteum, and disturbance of function of the affected part. The condition is not inaptly called by the laity "stone bruise." As affecting the os calcis it is common among country boys who go barefoot. Among adults the condition is notably frequent among laboring men as the result of contusions of the metacarpal bones and phalanges of the fingers from misdirected hammer blows and the like; further, among those who indulge in fisticuffs with naked hands.

Signs and Symptoms.—The signs and symptoms in these cases are local pain and tenderness over the affected bone, moderate swelling. Palpation in the case of the bones of the hand usually reveals thickening of the affected bone and some limitation of motion in the neighboring joint. The heat, redness, and great tenderness of a suppurative lesion are wanting, the condition tends to continue for weeks and months, and gradually to subside under massage, etc. In all these cases it is very desirable to take a pair of stereoscopic radiographs of the hand, since many of them will be found to be fractures with impaction and very slight deformity. If near a joint a small amount of deformity or the production of a small amount of new bone may permanently interfere with the function of the joint. A certain amount of pain is present for many months, and a greater or less degree of limitation of motion which may be permanent. The actual lesion is often so slight as entirely to escape any method of examination except a good X-ray picture.

CIRCUMSCRIBED OSTEOMYELITIS

Circumscribed foci of suppuration occur in the bones, in the epiphyses, and in the shafts of the long bones. The former is a primary disease among children, the latter more commonly the result of a previous attack of diffuse osteomyelitis. The primary epiphysitis is often multiple. The chief symp-

tom is pain of an intense boring character, worse at night and after using the limb. Tenderness is present over the abscess, and is due to secondary periostitis. The disease is apt to run rather a chronic course, and only in acute cases are constitutional symptoms marked. Secondary involvement of joints and destruction of the epiphyseal cartilage with separation of the epiphysis will give rise to characteristic symptoms. Such involvement is occasional. Locally there will often be little beyond the pain and tenderness to indicate the cause of the trouble, unless a secondary periostitis occurs with abscess of the soft parts, or unless a neighboring joint or the epiphyseal cartilage is invaded. In many instances, as already noted, a differential diagnosis from tuberculosis may not be practicable without operation. The chronic osteomyelitis of the shafts of the long bones will usually have the history of a previous attack of acute bone inflammation or of a bone injury complicated by infection. In the presence of a sinus leading to an ancient sequestrum or a chronic suppurating bone cavity the diagnosis is plain. When no such open lesion exists, pain will be the prominent and sometimes the only symptom. Tenderness will be present over the focus if periostitis coexists, and will serve as a guide for surgical interference. Periosteal thickening is usually present in these cases, and gives the physical signs of an enlargement of the bone.

TUBERCULOUS OSTEOMYELITIS

Tuberculosis of the bones so often affects their epiphyses, and is so often associated with secondary joint tuberculosis, that much that has been said under tuberculosis of joints applies also to tuberculosis of bone. Occurring as a separate affection independent of joint disease, tuberculosis affects the epiphyses commonly, more rarely the shafts of the long bones or the bodies of flat or spongy bones. The disease affects males more commonly than females, and is a disease of childhood and youth. Other foci of tuberculosis are often present or appear later in life. In the epiphyses of the long bones a tubercular focus may exist without producing symptoms.

Signs and Symptoms.—Pain.—There is usually pain, more or less marked, but of a variable intensity and intermittent, of a dull aching character, worse at night. Children with beginning bone tuberculosis often wake crying, or are restless, grind their teeth, or have bad dreams. The pain is sometimes a referred pain, a classical example being the pain of tuberculosis of the upper end of the femur, usually referred to the knee. On the other hand, in the phalanges of the fingers a central tubercular focus may occupy the entire phalanx, and produce the characteristic spindle-shaped enlargement (Spina ventosa) and be accompanied by no pain. Tuberculous osteites of the ribs are rarely painful.

Tenderness.—The most important diagnostic sign in the detection of early bone tuberculosis is tenderness over the point of disease in the bone. It is caused by a secondary periostitis, and a point of tenderness appearing

over the epiphyseal end of a long bone in a child, enduring for a time and slowly growing more marked, is very suggestive of tuberculosis of the bone. If joint involvement can be excluded, the moment is often most favorable for the operative eradication of the disease.

Swelling.—The presence of a tuberculous focus in the epiphysis of a long bone does not cause swelling or enlargement of the bone; such swelling as occurs is due to thickening of the periosteum or infiltration of the soft parts. In the shafts of long bones, on the other hand, a localized or diffuse swelling occurs when cortical bone absorption goes on hand in hand with a periostitis. Such periostitis may produce enough new bone to preserve the hardness of the cortical layer, or a parchment crackling may be felt upon firm pressure, or, in more advanced cases when the bone is perforated, a secondary tuberculous abscess of the soft parts forms, a boggy or fluctuating swelling having the characters of cold abscess, as elsewhere described.

Redness.—No redness of the skin is seen over a tuberculous focus in bone unless the skin is about to be perforated by tuberculous pus. A bluish or purple discoloration of the skin is then observed, not a vivid red, such as one sees in acute infections.

Atrophy.—Atrophy of all the tissues of a limb is a regular complication of those forms of tuberculosis of the bones and joints which involve disuse of the limb.

If a tuberculous focus is suspected in the epiphysis or of the shaft of a long bone, an aspirating needle or small trocar may sometimes be used to confirm the diagnosis. The withdrawal of tuberculous pus or cheesy material, or the discovery of a cavity in the bone by this means, should, if possible, immediately precede the operative removal of the focus. A good X-ray picture will often show such foci quite distinctly. Should a sinus exist, the introduction of a probe will often serve to detect rough carious bone or a bone cavity. This method of examination should be followed at once by operation on account of the danger of destroying the protecting layer of granulation tissue lining such cavities, and thus causing local or general infection with tubercle bacilli or pus microbes.

SYPHILIS OF BONE

Syphilitic inflammation of bone occurs in the later stages of both the acquired and hereditary forms of the disease. The characteristic lesions are gummatous periostitis and osteomyelitis. Both destructive and productive changes occur; syphilitic caries and necrosis as well as the production of osteophytes, osteosclerosis, and diffuse hypertrophies. The bones of the skull, the shafts of long bones, clavicle, tibia, femur, are favorite sites. The short bones and the epiphyses of long bones are seldom affected. The lesions may be single or multiple, and may appear in one or several bones.

Syphilitic Periostitis.—Syphilitic periostitis occurs as a flat or slightly elevated, circumscribed, hard, elastic swelling upon the bone. Although not com-

mon until after the sixth month of the disease, such a lesion may appear with or soon after the secondary skin eruption.

Pain and tenderness may be moderate or severe, and the pain is worse at night. The skin is normal in appearance over the swelling. The process may end in the production of new bone by the inflamed periosteum; a rounded bony elevation is thus formed, and these syphilitic nodes, as they are called, are permanent. In other cases degenerative changes in the new-formed gummatous tissue occur. The swelling becomes more prominent and softer, elastic, and even fluctuating. The skin becomes red and infiltrated, and finally breaks down, leaving a round crater-form ulcer with undermined edges. The base of the ulcer consists of characteristic gummy material, resembling somewhat raw bacon in appearance. At the bottom of the craterlike cavity the bone is rough and eroded. Upon healing, rounded scars are left behind, firmly adherent to the bone. Along with the bone destruction there is often a productive osteitis around the edges of the gumma with nodular thickening and sclerosis of the spongy tissue.

Fig. 42.—Syphilitic Periostitis of the Shafts of the Radius and Ulna, Showing Slight Periosteal Thickening. The picture was taken very early in the development of the lesion. The initial lesion had occurred two years before. Chief symptom complained of, pain of a dull, aching character, worse at night, slight tenderness on pressure over the lower half of the radius and ulna. Rapid disappearance of symptoms by the use of iodid of potash and mercury. (Author's case.)

Favorite sites for these gummata are the frontal bone and the crest of the tibia. The smooth contour of the anterior surface of the tibia and the even line of the crest are permanently deformed by the formation of grooves, ridges, and bony nodules. The presence of these, together with the adherent scars, constitute a character picture of a formerly active syphilitic process. In certain situations, notably the phalanges of the fingers, the nasal bones, and the hard palate, the entire periosteum of the bone may be involved, the nutrition of the bone may be thus impaired to the extent that necrosis, complete or partial, takes place with the slow separation of a phalanx, the nasal bones or the whole or a portion of the hard palate as a sequestrum. Characteristic deformities are produced. (See Regional Sergury.) The effect of treatment upon gummatous periostitis in its early stages is curative; the bony nodes, once formed, are, however, permanent.

Syphilitic Osteomyelitis.—The inflammations of the bone substance itself may be in the form of circumscribed gummata, of diffuse gummatous inflammation, or of a productive osteitis. These lesions are commonly associated with periostitis, also of a productive character; hyperostoses, enlargements, thickenings of the affected bone are produced. The gummatous process is, on the other hand, primarily destructive and associated with bone absorption. This combination of destruction and formative inflammation causes quite characteristic bone changes—the bone is enlarged, its normal outlines are destroyed, the surface rough and worm-eaten in appearance, cavities are formed here and

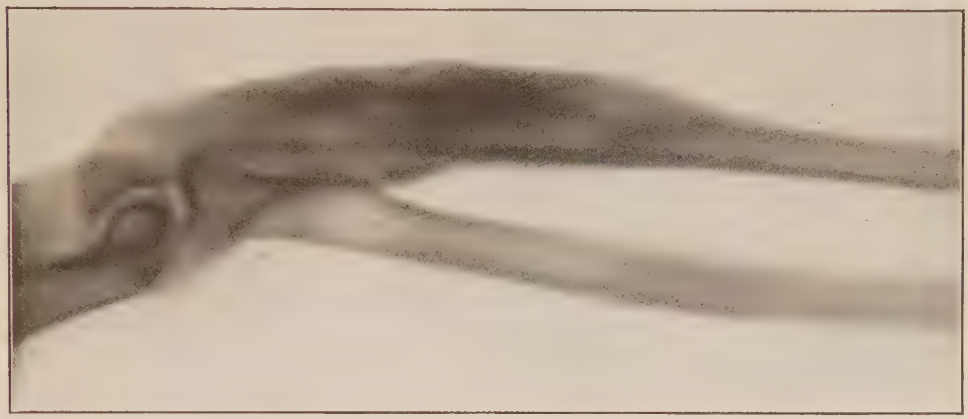


Fig. 43.—Productive Syphilitic Osteitis of Ulna, Showing Great Enlargement of Bone. Chief symptom pain; initial lesion seven years before. (Author's case.)

there, and if the entire shaft of a bone is occupied by a gumma spontaneous fracture may occur, sometimes in several bones in succession. The appearance of these syphilitic bones is so characteristic as to be unmistakable, and in the dried bones of ancient graves we can thus recognize the existence of syphilis among the earlier races of men.

Gummatous osteomyelitis may exist for long periods without objective signs. The characteristic bone pains, worse at night and sometimes of a severe and torturing character, are nearly always present. Percussion over the affected area is painful. The objective signs observed may be a spontaneous fracture. This may occur very early, even before severe pain has been felt, and may be the first evidence of serious bone disease. More commonly the secondary productive periostitis leads to a more or less fusiform enlargement of the shaft of the bone. Later, if untreated, softening and perforation of soft parts leads to the formation of abscesses and sinuses, which discharge broken-down gummy material, thin pus, and fine bone detritus, so-called bone sand. A probe introduced into such a sinus often penetrates deeply into the medulla of the bone, and touches here crumbling cancellous tissue and there a hard sequestrum.

Syphilitic Osteomyelitis of Flat Bones.—Syphilitic osteomyelitis of flat bones, such as the bones of the skull, presents a rather different picture.

A painful, tender, hard, rounded swelling appears, covered by bone; slowly or rapidly the outer table of the skull is perforated, the tumor becomes softer, and finally fluctuates; the overlying skin becomes brownish-red in color and ulcerates; broken-down gummy material is discharged; a crater-form ulcer is left behind, extending deep into the bone; further ulceration follows, and the internal table is sometimes perforated. These perforations are often round or oval in shape, and may be large or small. If the hard palate was involved, an abnormal communication remains between the mouth and the nose. If the vault of the skull, the distention of the internal table may produce symptoms of compression of the brain. The rapidity of the process in syphilitic osteomyelitis varies within wide limits; generally speaking, the process is slow, and may extend, with exacerbations, over months and years; on the other hand, notable bone destruction may take place in a few weeks.

Fig. 44.—Gummatous Inflammation of the Frontal Bone with Perforation of the Skull. (New York Hospital Museum.)

Differential Diagnosis.—In regard to the differential diagnosis between bone syphilis, acute osteomyelitis, tuberculosis, subacute or chronic osteomyelitis, and malignant new growths, it may be said that acute osteomyelitis runs a far more rapid and acute course, and is not attended by enlargement of the affected bone, though the swollen periosteum may cause apparent enlargement. (See, however, Periostitis, Albuminosa, and Sclerosing Osteomyelitis.) Chronic and subacute osteomyelitis nearly always follows an acute attack. Tuberculosis affects the epiphyses in a large proportion of cases. Malignant new growths cause, as a rule, a more rapid enlargement of the bone, with more sharply marked boundaries. One of the best means of diagnosis in bone syphilis is the administration of inunctions of mercury and of increasing doses of potassium iodid, pushed until the limit of tolerance is reached. Syphilitic lesions will be cured or improved by this means. Bone of new formation cannot be made to disappear, nor can sequestra be removed in this way, but pain will be lessened or cured, ulcerations will heal, gummata and periosteal infiltrations will fade away, and the clinical picture will nearly always change for the better. Nonsyphilitic processes will be unaffected.

Bone Lesions of Hereditary Syphilis.—Bone lesions may make their appearance during infancy, or even before birth, or they may be delayed until ado-

lescence—four to fifteen years. One of the most frequent forms during infant life and childhood is an inflammation of the epiphyses of the long bones involving the epiphyseal cartilage—an osteochondritis, sometimes attended by destruction of the cartilage and separation of the epiphysis. Tibia, radius, and ulna and humerus are the bones usually affected. A fusiform or ring-shaped swelling is formed at the junction of the epiphysis with the shaft. The deformity is not unlike that produced by rachitis. The bone adjoining the cartilage is softened, and its continuity may be preserved by the thickened periosteum merely. Spontaneous fracture or diastasis may occur from slight degrees of violence. There is commonly severe pain and tenderness along the epiphyseal line; the child screams violently when the part is pressed upon. The limb is powerless and is not moved (Pseudoparalysis syphilitica—Parrot). In case the epiphysis becomes separated from the shaft, a point of abnormal mobility can be felt, but crepitation is often absent. Angular deformities at the junction of the ribs with their cartilages and at the ends of the long bones of the extremities may follow. Suppuration is not infrequent, the soft parts overlying the joint become swollen, edematous, and of a pasty consistence. Ulceration follows, of a typical syphilitic character; sometimes the neighboring joint becomes involved in the inflammation. In case the vital connection of cartilage between shaft and epiphysis is destroyed, the growth of the bone is interfered with. In some cases the process is of a more irritative character; an overgrowth of bone takes place; the bone becomes longer than normal. In syphilitic children, from the fourth year upward syphilitic periostitis of the formative variety is not infrequent. The tibia is often the seat of the process. The bone becomes enlarged, thickened, and deformed; the normal outlines are lost; anterior curvature is common, as well as flattening from side to side. Knock-knee and flat-foot sometimes result from uneven growth of the tibia and fibula.

In hereditary syphilis of the late type—i. e., symptoms first developed from the fourth to the eighteenth year—the bones, the permanent teeth, and the cornea are affected in a considerable proportion of cases. The bone lesions are as described. The narrow, short, central incisor teeth, with rounded notches upon their cutting edges, and keratitis, form, when present, an unmistakable group of symptoms.

RACHITIS

Rickets is a disease of the general nutrition occurring in infants and young children up to the age of puberty. It is supposed to be due to imperfect feeding during the first year of life, early weaning, too much starchy food, etc. The disease may be evident at birth (achondroplasia, fetal rachitis), more commonly it develops during the first two or three years of life. The symptoms are local and general. The general symptoms are disturbances of the bowels, diarrhea or constipation, a prominent belly; profuse sweating, notably about the head and at night; bronchitis, delayed dentition, delayed closure of the fontanels. The liver may be diminished in size.

The spleen is sometimes enlarged. Phosphaturia is commonly observed. Chronic hydrocephalus and arrest of or imperfect cerebral development are not infrequent.

Fig. 45.

Fig. 46.

Figs. 45 and 46.—Photographs of a Case of Achondroplasia Congenita, So-called Fetal Rachitis. The patient was a woman aged about thirty years. Nearly all the bones of the skeleton were of abnormal shape or abnormally proportioned. There was a very marked exaggeration of the dorsal curve of the spine and marked lordosis in the lumbar region. The antero-posterior diameter of the pelvic brim was not more than one and one half inches. The patient was very intelligent and enjoyed excellent health.

Rachitic children are peculiarly liable to attacks of spasm of the larynx (Laringismus stridulus). The child does not learn to walk readily. Either with these signs and symptoms, or later, there are developed peculiarities and deformities of the bony skeleton. There is imperfect ossification and enlargement at junctions of the shafts of the long bones with their epiphyses; the lower end of the radius, the lower end of the tibia, and the ribs at the costo-chondral junctions show fusiform swellings. The skull departs from the normal shape. The calvarium is often higher than normal, and is compressed either antero-posteriorly or laterally; the fontanels remain open sometimes until

the end of the second year; the top of the skull may remain imperfectly ossified, and in parts remain of a parchmentlike consistence (Craniotabes rachitica). Dentition is delayed, imperfect, or irregular; there is commonly a gothic or arched hard palate.

The antero-posterior diameter of the thorax is increased in its upper part and compressed laterally; the sternum is prominent and the costochondral junctions are enlarged and palpable; there is a groove along the line between the ribs and their cartilages; the lower ribs project outwardly, thus the transverse diameter of the thorax is increased at its lower part. Deformities of the pelvis are common and endure through life. The antero-posterior diameter of the pelvic girdle is diminished, or less often the pelvis is compressed laterally so that the superior opening of the pelvis has a shape resembling that of the ace of hearts. Curvatures of the femur and of the tibia and fibula are common. The curvature of the femur may be convex anteriorly or to the outer side. The tibia is often curved outwardly (Genu varum—bow-legs) or anteriorly; the crest of the tibia then appears prom-

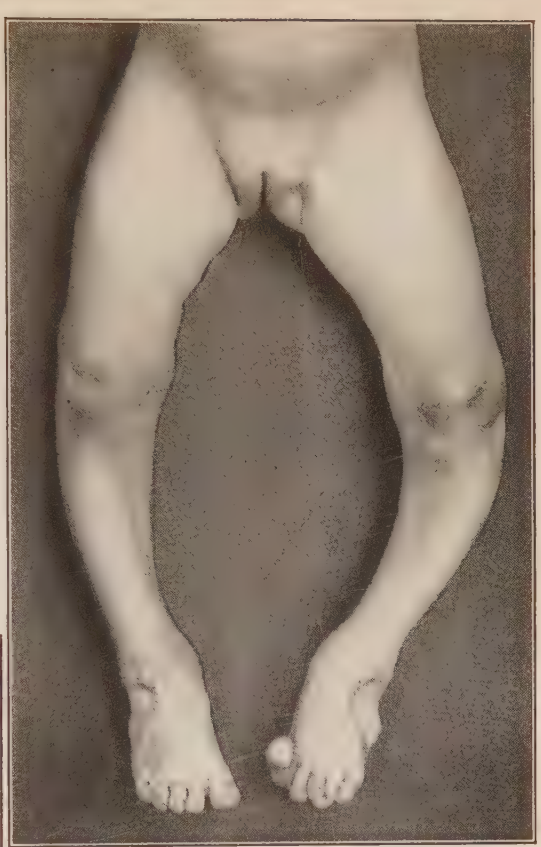


Fig. 47.—A Marked Condition of Bow-legs (Genu Varum). (Collection of Dr. Charles McBurney of Roosevelt Hospital.)

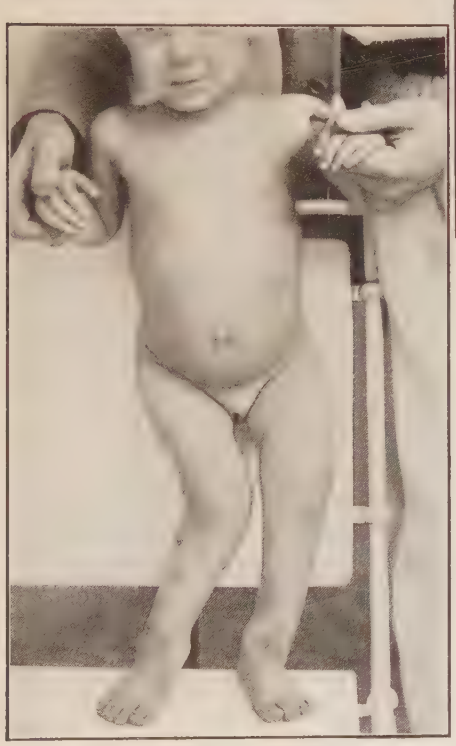


Fig. 48.—A Marked Condition of Knock-Knee Associated with Rachitis. The enlargement of the epiphyseal ends of the tibia and fibula at the ankle-joint are well shown. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

inent, and the bone may be compressed laterally. Sometimes combinations of anterior and lateral curvatures occur; genu valgum is less common. The spine often shows a lateral curvature (scoliosis) or an antero-posterior curvature (lordosis or kyphosis).

All these deformities are so characteristic that the diagnosis of rickets is usually very simple. It is only necessary to remove the clothing from the child and inspect its naked body to recognize the more typical cases of the disease. After these patients grow older and ossification is complete their bones may become exceedingly dense and hard.

FIG. 49.—CASE OF ACROMEGALY OCCURRING IN THE SERVICE OF DR. FRANK W. JACKSON IN BELLEVUE HOSPITAL, THROUGH WHOSE KINDNESS I AM ABLE TO HAVE THE ACCOMPANYING ILLUSTRATIONS REPRODUCED.

NOTE.—The pathological report of this case was published by Dr. Charles Norris, who very kindly gave me the photographs. The patient's symptoms had existed for nearly five years and consisted in a gradual and characteristic enlargement of the hands, the feet, and the face; together with dimness of vision due to atrophy of the optic nerve. During the last year of his life he had from time to time epileptic convulsions and continuous headache. His mental faculties were impaired, as shown by progressive loss of memory and by fits of irritability. He died in Bellevue Hospital in January, 1907. Death was preceded by a series of severe convulsions after which the patient became comatose, with Cheyne-Stokes respiration and died. The case was reported in full by Dr. Charles Norris in the "Proceedings of the New York Pathological Society." New Series, vol. vii, No. 1.

OSTEOMALACIA

Osteomalacia is a rarefying osteitis, combined with loss of earthy material of the bone. It is a comparatively rare disease, occurring in women during and after pregnancy. Two sets of phenomena are observed: the bones may undergo spontaneous fracture from very slight degrees of violence, or the bones become so soft that bends and deformities of the long bones occur in all directions and to extraordinary degrees. In addition, neuralgic pains of severe character are present, together with progressive cachexia, usually leading to a fatal issue in a year or two.

OSTEITIS DEFORMANS

Osteitis deformans is a rarefying osteitis affecting the entire skeleton; the disease affects males more often than females, and does not occur until near the fiftieth year of life. The characteristic signs are pain in the affected bones, enlargements and curvatures of the bones of the extremities, progressive muscular weakness. The onset of the condition is slow and insidious. The tibia and femur are first affected; they become thickened and bowed anteriorly. Subjectively

the limbs feel heavy, and locomotion becomes difficult from muscular weakness and pain. The bone changes can be well shown by a radiograph. In a case under my observation the tibia was notably enlarged and bowed anteriorly. The X-ray picture showed thinning of the cortical layer, a marked increase in size of the spaces of the cancellous tissue, and the formation of irregularly shaped cavities in the cancellous tissue bounded by thin, bony lamellæ. As the disease progresses, other bones are affected. The spine loses its flexibility, and is bowed forward so that the patient's chin projects, while the thorax sinks toward the pelvis. The shoulders are rounded and the arms hang forward, and lower than normal. The attitude suggests that of some of the manlike apes. The muscular weakness and deformity continue slowly to increase; death occurs finally from exhaustion or from some intercurrent disease.

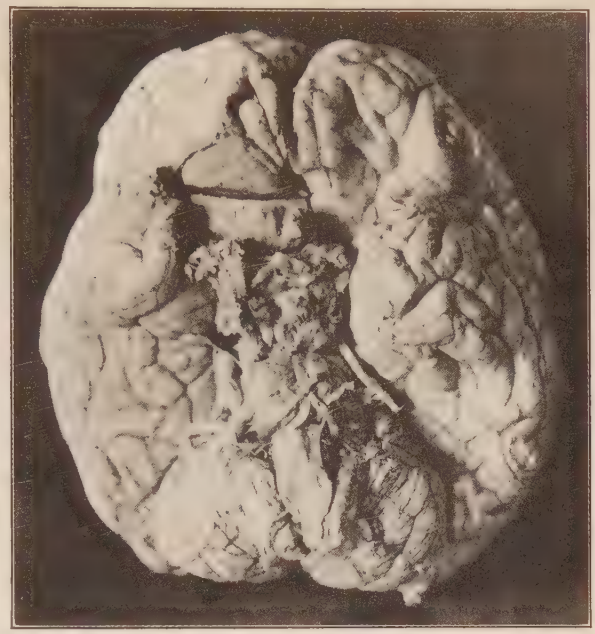


FIG. 50.

FIG. 51.

FIGS. 50 and 51.—THE BRAIN OF PATIENT IN CASE SHOWN IN FIG. 49, SHOWING RESPECTIVELY THE BASE OF THE BRAIN, WITH THE TUMOR IN SITU AND A FRONTAL SECTION OF THE BRAIN THROUGH THE TUMOR OF THE PITUITARY BODY.

ACROMEGALY

Acromegaly is a disease of obscure nature, and rather rare, commencing during the second or third decade of life, and characterized by an hypertrophy

of the bones and soft parts of the hands, forearms, face, and feet, and by disturbances of the mental state: mental dullness, emotional disturbances, sometimes melancholia. The nervous reflexes are disturbed—sometimes exaggerated, sometimes diminished. There is muscular weakness and a general enfeeblement of the entire organism. The appearance of these people is so characteristic that a diagnosis can usually be made at a glance (see illustration). The face, notably the lower portion including the lower jaw, is abnormally large; the expression is dull and listless. The hands, forearms, and feet are abnormally large. The skin is normal in appearance. The disease is sometimes associated with malformations of the sexual glands and enlargement of the pituitary body.

LEONTIASIS OSSIUM

Another obscure condition is Leontiasis Ossium. There is a diffuse hypertrophy of the bones of the face, notably of the upper jaw, and the formation of circumscribed outgrowths of cancellous bone tissue in the same region. These bony masses cause serious symptoms by pressure in the orbit, in the nasal fossæ, and the base of the skull, interference with respiration and vision, or, by growing into the cranial cavity, cerebral symptoms from compression of the brain.

CHAPTER VI

DISEASES OF THE SOFT PARTS

GANGRENE

Death of circumscribed masses of tissue—variously known as gangrene, mortification, necrosis, sloughing, sphacelation—occurs when the tissue cells are deprived of their proper nutrition or are killed by mechanical, chemical, or other means. The term gangrene is commonly used to describe the condition of death when associated with the phenomena of decomposition (mortification), and indicates that putrefactive changes have occurred in the dead part. The dead part is known as a sphacelus or slough. Necrosis is commonly used to designate the death of bone or the death of a limited portion of tissue without decomposition.

Causation.—Gangrene may occur from a variety of causes: Cessation of the blood supply to the part by obstruction of the main artery of a limb. Obstruction of the veins such that the blood cannot return to the general circulation. Obstruction of both arteries and veins. Obstruction of the smaller arteries and veins or of the capillaries. The obstruction may be due to injury of the vessels themselves, as when the main artery of a limb is crushed, torn, cut, or ligated. It may be due to mechanical pressure from effused blood around a ruptured aneurism, a foreign body, a tumor, a fractured or dislocated bone, unduly prolonged application of an elastic ligature around a limb for the control of bleeding, a circular plaster-of-Paris dressing too tightly applied in cases of fracture, or to compression of the tissues between bony points and the bed in depressed states of vitality. Further, diseases of the blood-vessels: thrombosis, embolism, obliterating arteritis, arteriosclerosis.

Numerous other conditions not directly connected with the blood-vessels themselves may cause or predispose to the occurrence of gangrene. Crushing injuries destroy the vitality of the tissue cells. Bacterial invasion of wounds is a direct cause of gangrene in some cases; in others the bacterial poisons act in conjunction with general or local states of enfeebled vitality. Extreme degrees of heat and cold destroy the vitality of the tissue cells. Certain poisons and caustics—snake venom, carbolic acid, nitric acid, etc.—produce coagulation of the tissue elements and necrosis. The radiations from an X-ray tube may cause sloughing of the tissues. Predisposing causes of gangrene are extreme

anemia, acute or chronic alcoholism, senility, diabetes, diseases of the heart and lungs or vessels producing venous congestion, acute infectious diseases. Further, certain diseases of the nervous system: tabes, cerebral palsies, division of nerve trunks, and diseases of the trophic nerves. These various conditions, combined with mechanical injury and bacterial infection, often determine the occurrence of gangrene.

Symptoms.—Clinically the local and general signs and symptoms of gangrene vary a good deal, according to the character of the affected tissue and its relation to the neighboring living parts; further, according to the presence or absence of bacterial infection, putrefactive or pyogenic, one or both. When the arterial circulation of a part slowly ceases while the veins remain patent, but little water remains in the tissues, and the conditions are unfavorable for putrefactive change. Such conditions are present in the gangrene of the toes and feet of old people, due to slowly progressive arteriosclerosis of the vessels of the foot and leg. In some of these cases a spreading thrombosis of the capillaries and arterioles stops the circulation. In others, thrombosis of the larger arteries is found together with advanced atheroma of these vessels (GANGRENA SENILIS). In many of these cases the gangrene is of the dry aseptic type (DRY GANGRENE—MUMMIFICATION).

FIG. 52.—DRY GANGRENE OF THE FOOT.
(New York Hospital, service of Dr. Frank Hartley.)

Course of the Disease.—Prodromal symptoms may precede; there is subjective and objective coldness of the toes; pain, sometimes dull, sometimes sharp and neuralgic in character. Such symptoms may be present for weeks or months, or the gangrene may occur without warning. After some trifling contusion or abrasion, or without such, a spot of dusky discoloration appears upon a toe, and slowly increases in size, gradually involving one, several, or all the toes or a large part of the foot.

The dead tissue is dark greenish-brown in color, hard, dry, shriveled, and insensitive. Putrefactive changes are slight or absent.

A line of demarcation between the living and the dead tissue is formed in many of these cases. The upper third of the calf of the leg, below the bifurcation of the popliteal artery, is rarely passed in this form of gangrene. The dark-colored dead tissue ends abruptly at a certain level; above that the skin is reddened, hot and tender; a furrow forms by ulceration at the border of the living tissues and encircles the limb, gradually growing deeper until the soft parts are entirely separated and the dead part remains attached to the living merely by bone. Moderate suppuration accompanies the separation, as a rule. The skin usually dies at a higher level than the muscles, and the muscles at a higher level than the bone; hence, spontaneous separation leaves behind a conical stump. If nearly aseptic, this type of gangrene may be accompanied by little or no constitutional disturbance.

Moist Gangrene—Traumatic Gangrene

Moist gangrene is accompanied by putrefactive changes in the dead tissues, and is often associated with pyogenic infection. The gangrene following trauma is often of the moist variety. Moist gangrene may be localized or progressive. It occurs when the dead tissues remain saturated with fluid, thus favoring putrefaction. Sudden obstruction of the main artery or vein, or both, of a limb from injury or disease, severe trauma with much contusion and laceration of tissue, are the usual causes of moist gangrene. The determining factor is always the presence of infection with saprophytic and pyogenic germs.

Signs and Symptoms of Localized Moist Gangrene.—Pain in the part ceases; the limb becomes cold, white, pulseless, insensitive, and useless. Coagulation of the muscle plasma causes rigidity of the muscles (rigor mortis), lasting for some hours. The skin surface becomes mottled with blue or dark-red blotches. A general greenish-brown discoloration follows. The living skin above is red, swollen, tender, and hot. Red streaks of lymphangitis can sometimes be seen running upward toward the trunk. Blebs form upon the skin of the gangrenous area filled with brownish, stinking fluid, sometimes with gas. The dead tissues may also crepitate from the generation of the gases of putrefaction. The epidermis forming the blebs can be slid about easily upon the underlying green or dark purplish-red, softened cutis. Upon cutting into the limb, blood-stained, brown, stinking fluid escapes. The muscles are soft and pulpy, at first dark-red or brown in color, later greenish-black and semifluid. The further changes are simply those of advanced putrid decomposition, with liquefaction. The living tissues above the limit of the gangrene are in a condition of more or less acute purulent infection. There is profuse suppuration at the line of demarcation, progressive ulceration and final separation of the dead part, or death of the individual from septic and saprophytic absorption.

Malignant Edema—Gangrène Foudroyante—Emphysematous Gangrene

The bacillus of malignant edema (*vibrion septique* of Pasteur) causes by far the most dangerous and fatal form of gangrene. It is a rod-shaped bacillus, usually with rounded ends. The rods vary in length from 3 to 10 μ; they are motile, and possess flagella on the sides; sometimes the rods grow into long filaments. It is an anaërobic germ and forms spores. It is not easy to identify under the microscope.

In gelatin plates, under anaërobic conditions, the colonies appear as small whitish points, which under a low power show radiating appearances soon masked by a mask of liquefaction. In deep tubes of glucose gelatin the growth appears as a whitish line, giving off minute short processes, never reaching within an inch of the top of the medium, with the occurrence of liquefaction and the settling of the colonies to the bottom. In deep tubes of glucose agar at a temperature of 37° C. the growth is very rapid, as a broad white line along the line of puncture, with lateral projections here and there and a very profuse production of gas. The cultures have a peculiar heavy odor that is quite characteristic. The growth is rapid; it produces spores that are well seen within forty-eight hours at 37° C.; it produces gas, liquefies gelatin, and stains easily with any of the anilin colors, but not by Gram's method; upon subcutaneous inoculation in any susceptible animal it produces the characteristic symptoms of widespread edema, gas production, and gangrene.

Cultures may be made in glucose gelatin as roll cultures, and kept under anaërobic conditions. If the bacilli contain spores the fluid may be kept at a temperature of 80° C. for ten minutes, and then a deep glucose-agar tube should be inoculated and kept at the temperature of the body. An inoculation experiment with the suspected material may also be tried on guinea pigs. (H. C. Ernst.) *Loc. cit.*

The process is essentially a rapidly progressive septic cellulitis, with grave constitutional poisoning, advancing hand in hand with putrid decomposition of the infected tissues. The onset of the disease is sudden, following an injury, a compound fracture, a gunshot wound, or a contused and lacerated wound, or, more rarely, some trifling puncture. After a day or two an area of hard, brawny edema of a dusky red or mahogany color appears at the wound edges and spreads rapidly up the limb. Constitutional symptoms of sepsis appear at once, and grow more grave from hour to hour. The limb becomes greatly swollen, and from the hand the necrotic inflammation may reach the shoulder in two days. Putrid decomposition of the part first affected takes place rapidly, and above the gangrenous area the hard, dark-colored infiltration advances. Subcutaneous emphysema due to the gases of decomposition is marked, and often extends far beyond the inflamed and necrotic area up on to the shoulder or to the groin and abdomen. Blebs containing stinking serum and gas form here and there upon the discolored skin. Incision into the limb permits the escape of stinking serum, but no blood. The vessels are filled with septic thrombi; the connective tissues look like raw bacon; the muscles are dark-red

or almost black, and soft. Here and there an abscess may be encountered, filled with stinking pus.

From the first the septic symptoms are grave. The temperature is at first elevated, later it often sinks to subnormal; the pulse is rapid, and continues to grow weaker. Delirium soon appears, followed by stupor and coma. The picture is that of intense septic intoxication, and ends fatally in a large proportion of cases. A few are saved by early amputation above the limit of the infection. Gangrene with putrid decomposition occasionally occurs primarily in the lung. In other internal organs, except the alimentary canal, emboli containing putrefactive germs must be brought to the part for the production of this form of necrosis.

To recapitulate the diagnostic signs which point to the death of a portion of the body: Arterial pulsation is absent in a limb about to become gangrenous; this sign cannot always be made out, nor is it positive when observed. Behavior of the tissues when pressed upon: Finger pressure upon a living portion of the skin produces a white, anemic spot; the normal pink color returns at once when the pressure ceases. Pressure upon a dead part either leaves its color unchanged or, if rendered paler, the color returns slowly and imperfectly, if at all. The normal elasticity of the tissues is lost, the skin pits on pressure, and the pitting remains or disappears but slowly and imperfectly. Puncture of a living part is followed by bleeding, puncture or incision of dead tissues is not, or a little dark, venous blood may appear, and if the tissues are squeezed dry of their contained blood the bleeding ceases permanently. An abrasion of the skin over a dead area does not remain moist from exuded serum, but rapidly dries, remains so, and in a few hours turns brown in color. The sensibility of a dead part is lost, and the loss of sensibility does not correspond to an area of nerve distribution, but ascends to a more or less uneven level. The function of a dead part is abolished. It is to be borne in mind that live forearm muscles may still, for a time, move dead fingers. The temperature of a dead limb is lower than normal, and finally falls to that of the surrounding atmosphere. The color of a gangrenous part is variable in the early stages. Stoppage of arterial circulation renders the part pale; venous obstruction, blue or dark red; later, mottling of the skin occurs, blue livid areas alternating with white or dusky red. When gangrene is fully developed the changes are so marked as to be evident to any eye, as already described.

Diabetic Gangrene

Persons suffering from diabetes are peculiarly susceptible to pyogenic infections. The vitality of their tissues is lowered, and a considerable proportion of them suffer from arteriosclerosis of the arteries of the extremities. While gangrene more commonly occurs in diabetics beyond middle life, yet younger individuals, who except for their diabetes appear in fair health, also suffer. The occurrence of gangrene is commonly associated with an increased amount

of sugar in the urine, and this increase often goes on with the spread of the gangrene and diminishes after amputation. Spontaneous gangrene of the toes in middle life leads us to look for the thirst, polyuria, and glycosuria of diabetes.

Varieties.—Two forms of tissue necrosis occur in these cases: *First*, ordinary gangrene, usually of the moist type, beginning in a toe, either spontane-

Fig. 53.—Diabetic Gangrene of the Foot Following Pott's Fracture. (New York Hospital collection.)

ously or after a trifling injury such as the paring of a corn or a slight contusion. Sometimes a chronic ulcer of a toe has existed for weeks or months, slowly growing deeper and larger before the gangrene appears. There is little tendency to limitation of the gangrene in these cases; it is usually slowly or rapidly progressive, according to the intensity of the associated pyogenic infection and the resisting power of the individual. These patients often

become septic or pass into diabetic coma, and gangrene of the flaps, even after high amputation, is only too common. A diminished quantity of sugar, as the result of diet or after amputation, is of rather favorable significance.

The *second* form is rather a phlegmonous inflammation of the foot, beginning in some trifling wound or ulcer, and runs a rather insidious course, without much constitutional reaction or signs of acute inflammation. The wound or ulcer is found to be slowly growing deeper, and one day it is noted that pressure upon the sole of the moderately swollen foot causes pus to escape from the distant opening. An extensive burrowing abscess with necrosis of the connective tissue may thus be discovered whose extent was unexpected. The sloughing and burrowing usually proceed in spite of local treatment, and amputation offers the only hope of survival.

Dry Senile Gangrene

Dry senile gangrene has already been described. Senile gangrene is not always of this type; it is often associated with putrefaction and more or less intense pyogenic infection, with septic symptoms, lymphangitis, abscesses, etc.

Gangrene Due to Arteriosclerosis in Early Middle Life—Presenile Gangrene—Erythromelalgia—Intermittent Claudication

Localized arteriosclerosis of the arteries of the lower extremity occurs in persons from thirty to fifty years of age. It is notably common in natives of certain parts of Russia and Poland. It is thought by some observers to be of syphilitic origin. The symptoms are characteristic; the individual suffers from pain of a burning character in the feet and toes when walking. In addition, there are sensations of heat and cold, numbness, formication and other paresthesiæ, weakness of the muscles, and lameness. The symptoms disappear if the patient keeps off his feet, and reappear when he again walks. The toes are often pale, sometimes blue, swollen, and congested. The posterior tibial and dorsalis pedis pulses are weak or absent. Sooner or later an ulcer appears on one toe or along the border of the foot, and assumes a progressive or gangrenous character; a considerable part of the foot may be involved. The age of the patient, the severe pain, and the disappearance of the early symptoms when the patient refrains from walking suffice for the diagnosis.

Gangrene from Embolism and Thrombosis of the Main Artery of a Limb

The artery involved is usually the femoral or the popliteal; the condition is rather rare; it occurs as a complication of endocarditis, in the course of acute infectious diseases—typhoid fever, pneumonia, measles, scarlet fever, influenza, etc.; contusions of the thorax and abdomen have been followed by

injury to the abdominal aorta and embolism or thrombosis of the iliac or femoral vessels. A number of cases are on record of gangrene following thrombosis of the aorta in acute infectious disease. The gangrene has been unilateral or symmetrical—i. e., of both legs. If a large artery is suddenly plugged by an embolus, severe pain is felt in the entire limb; there is muscular weakness or paralyses, rigidity of the muscles and cramps; the

FIG. 54.—MOIST GANGRENE OF THE FOOT FROM DIABETES. Recovery after amputation at the middle of the thigh, with marked improvement in the diabetic symptoms. (New York Hospital, service of Dr. F. W. Murray.)

limb becomes useless, cold, and pale. If collateral circulation is established the limb gradually becomes warmer, and circulation can be demonstrated by pressure on the finger- or toe-nails. The functions of the limb may be gradually restored or ischemic degeneration of the muscles and permanent atrophy of the limb may follow. No collateral circulation being established, gangrene

of the dry or moist variety, according to the absence or presence of infection, results.

When the thrombosis or embolism occurs in the course of acute diseases where the patient is already very ill, the first warning may be the coldness, bloodlessness, and paralysis of one or more extremities. It sometimes happens that the obliterating endarteritis of the later stages of syphilis affects the larger or smaller arteries of the extremities, and thrombosis or obliteration of their lumena may follow with the production of gangrene. Such gangrene is sometimes symmetrical; both hands or both feet may be involved. Gangrene due to injury of or pressure upon the main artery of a limb may be caused by incised or punctured wounds of the artery, by contused wounds, or contusions of the arterial wall. If gangrene ensues, its causation will usually be evident. Displaced fragments of bone in fractures and the pressure of dislocated bones may occlude the main arterial trunk; the cause of an ensuing gangrene should be plain to the surgeon. Pressure from tumors and foreign bodies and from the effused blood of a ruptured aneurism may cause gangrene of an extremity. Thrombosis or embolism of the main artery of a limb may cause gangrene. In the case of the lower extremity, gangrene is rare from obstruction of the artery alone unless the common iliac is involved.

The following case of thrombosis of the common iliac artery followed by gangrene of the entire lower extremity is quoted as an illustration of this rather rare condition. In this case it is not improbable that an embolism of the popliteal was followed by a thrombosis extending upward to involve the common iliac:

A young man, twenty-eight years of age, was admitted to the hospital with the following history: Very marked chronic alcoholism for a number of years; syphilis three years ago. Of late has been on a prolonged alcoholic debauch. Two days before admission he was suddenly seized with complete loss of power in the entire left lower extremity and very severe pain, referred especially to his leg. On admission, patient apathetic, cerebration imperfect and sluggish. Temperature subnormal; pulse, 124 and feeble; respiration, 28. Left lower extremity completely powerless. Insensitive as far upward as the knee, and coolness up to same point. Skin of foot and leg; mottled reddish-purple areas alternating with dead white; no evidence of cutaneous circulation to a point above the knee. In spite of various efforts, the discoloration, paleness, coldness, and loss of sensibility continued to advance during the following days. Pain ceased in the limb. After three days it was evident that the entire lower extremity was without circulation; no evidences of saprophytic or pyogenic infection. General condition steadily grew worse. Amputation just below hip-joint. Wound entirely bloodless; common femoral contained a thrombus. Death three days later in coma. Examination showed right common iliac artery plugged by a firm thrombus. No definite lesion found to account for the condition.

Gangrene from Escharotics

The application of acids, alkalis, and other caustics to skin or mucous membranes causes local necrosis. The appearances vary; sulphuric acid produces a greenish-black slough. Nitric acid forms a bright yellow, later yellowish-brown, chemical combination with the tissues, known as murexid. Nitrate of silver a superficial black stain. Chromic acid a greenish-brown slough. Trichloracetic acid a white slough. The caustic alkalis KOH and NaOH a black slough. Zinc chlorid a whitish-gray discoloration. Carbolic acid a white slough, turning greenish-black or copper-colored later. (See Stomach.) Gangrene of fingers from the improper use of carbolic-acid wet dressings by the uninformed laity is very often seen in city dispensaries. So weak a solution as one per cent has been known to produce sloughing after a day or two. Five per cent will destroy a finger in a few hours. Since carbolic acid is anesthetic, relief from pain gives the patient a sense of false security.

Fig. 55.—Carbolic-Acid Gangrene of a Finger. Patient applied a dressing of crude undiluted carbolic acid to his finger. (New York Hospital, Out-Patient Department, case of Dr. Hitzrot.)

The Effects of Cold upon the Tissues

Prolonged exposure of the tissues to a temperature below freezing causes gangrene. The fingers and toes, the ears, tip of the nose, and cheeks are the parts usually affected. Want of food, fatigue, alcoholism—acute or chronic—and debility from any cause favor the occurrence of frostbite. A frozen part becomes pale, white, hard, and insensitive. Upon the return of circulation, red, hot, tender, swollen, and painful. A common mild form of frostbite occurs in the toes and fingers of improperly clothed children (perniones—chil-

blains). Upon returning to a warm place after exposure to cold, the toes become hot, swollen, red, and tender. Intense itching is complained of, notably at night in bed. In a more severe form thrombosis of the capillaries occurs, and a superficial ulcer forms on one or more toes. When a part is actually frozen and is to become gangrenous, thawing and return of blood current is accompanied by extravasation of blood through the walls of the dead capillaries; the part is stained a deep-blue color or purplish-red; other parts may remain white and pale from thrombosis of the arteries. There is often a good deal

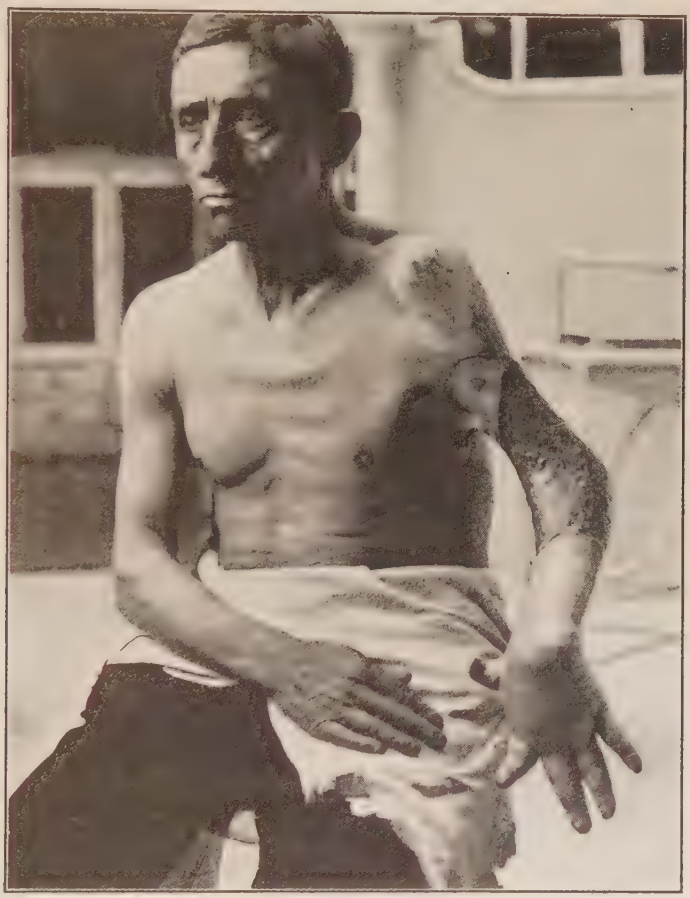


FIG. 56.—CICATRICIAL CONTRACTION FOLLOWING EXTENSIVE BURN OF THE UPPER EXTREMITY WITH COMPLETE LOSS OF FUNCTION. A large unhealed area of granulation tissue occupies the region of the elbow and upper arm. (New York Hospital collection, author's service.)

of pain, but loss of cutaneous sensibility. The phenomena of gangrene follow, dry or moist, and with or without symptoms of sepsis, according to the presence or absence of bacterial infection.

The Effects of Heat

The destructive effects of heat may be produced by radiant heat, by flame, by hot fluids, or solids. The effects of hot fluids are known as scalds. The symptoms are local and general.

General Symptoms.—The severity of the general symptoms depends more upon the extent of cutaneous surface involved than upon the depth of the burn. The charring of a foot may not be followed by serious constitutional symptoms. A superficial burn of one half of the cutaneous surface is usually attended by fatal shock. Shock is marked in burns of the trunk and head. If shock is severe, the patient may pass at once into a stupid or comatose state, from which he does not recover. In less severe cases there is often restlessness and excitement. A chill may follow a severe burn, the pulse is accelerated, the temperature is usually subnormal; after twenty-four hours there is commonly a rise of temperature. Ulceration of the duodenum with perforation is an occasional complication, and acute exudative nephritis in some cases; hemoglobinuria is not uncommon; there may be vomiting and diarrhea, sometimes bloody diarrhea. The later complications of severe burns are septic absorption from infection of the burned surfaces, acute and chronic septicemia, and exhaustion.

Fig. 57. Extensive Scarring and Deformity of the Arm Following a Burn. Condition greatly improved by a plastic operation and skin grafting. (Collection of Dr. Charles McBurney.)

Classification. -The classification of burns suggested by Morton is here given: First degree— hyperemia, erythema, or inflammation of the skin without vesication; no scar results. Second degree—inflammation of the skin with vesication; no scar, but staining from pigmentation of skin follows. Third degree—in addition to all seen in the other degrees, destruction of the skin and subjacent tissues to varying degrees up to complete charring of the parts. Much of the subsequent scarring and deformity results not from the primary injury, but from consecutive sloughing or gangrene, and contraction of the new-formed tissue during and after healing.

Symptoms of Burns of the First Degree.—Pain, of a stinging or burning character. Redness of skin, which disappears on pressure and returns when the pressure is relieved; the redness persists for hours or days, and desquamation follows. Very extensive burns, even of this slight degree, may be attended by fatal shock.

Burns of the Second Degree.—There is intense burning pain in the injured area. Large and small blebs form on the skin at once or after several hours. The blebs are filled with clear serum; after twenty-four hours the serum may become cloudy. The blebs are usually ruptured by accident, and form a thin, wrinkled pellicle, freely movable over the moist, red, sensitive, true skin beneath. If the surface is kept aseptic and is not exposed to mechanical irritation, especially if the blebs are merely punctured after cleansing the surrounding skin, a new cuticle may form without any inflammatory reaction whatever within ten days. If not, some swelling, redness, heat, and a more or less copious discharge of pus occurs; this discharge dries into a scab or crust. The new surface beneath is red and granular in appearance; then gradually dries, and is covered by new epithelium. Frequently a smooth pigmented surface, at first red, then brown, remains; such pigmentation gradually fades, but may be evident for many months. The constitutional effects depend upon the size of the burned surface. Any form of pyogenic infection is possible in burns of this degree.

Fig. 58.—Deformity of Face and Neck Two Years After a Severe Burn. (Collection of Dr. Charles McBurney.)

Burns of the Third Degree.—Under this head are included all burns involving actual destruction of tissue, those causing the death of a part only of the thickness of the true skin, so that some of the deeper glandular organs lined with epithelium remain behind, as well as those involving the charring of

an entire extremity by flame or molten metal. The appearances vary greatly in different cases. The eschars may be pale yellow or white in color, or black, or brown, or ashen gray, and dry or moist. It is not possible at once to determine the depth to which the tissues have been deprived of their vitality. The separation of the sloughs takes place very slowly; by granulation if aseptic, by suppuration if infected. It is well-nigh impossible to keep extensive burns of this degree free from pyogenic germs. The extensive granulating areas contract as they heal, and scars, often of a disfiguring or crippling character, follow. Thus the chin may be drawn toward the sternum; the limbs may be held in a position of flexion; circular scars surrounding a limb may seriously interfere with its nutrition; scars involving the axilla may produce, by pressure upon the axillary vein, persistent edema of the entire upper extremity.

Gangrene from Injuries and Diseases of the Nervous System

Transverse lesions, traumatic or other, of the spinal cord—syringomyelia, transverse myelitis—are frequently complicated by gangrene of the extremities—fingers and toes, and by pressure necrosis of those soft parts lying over bony prominences—sacrum, os calcis, etc. Paralyzed limbs, and parts in which the nervous sensibilities are impaired, are predisposed to gangrenous and necrotic inflammations from two causes. The part receives less blood than normal—i. e., its nutrition is impaired; further, the diminished sensibility of the part renders the individual unconscious or indifferent to mechanical insults, such as blows, or continued pressure from a wrinkled stocking, a tight boot, etc.

One of the typical examples of this condition is found in tabes under the name of perforating ulcer of the foot (mal perforant). The patient develops a callous spot somewhere on the sole of the foot, on the ball of the great toe, or under the first metatarso-phalangeal joint. If the thickened cuticle is pared away, it grows again rapidly. Presently a spot appears in the center of the callus, which looks as though a drop of blood had been extravasated into it; if this is pared away a small round ulcer is found beneath, from which a little thin discharge escapes. If the patient continues to walk upon the foot, the ulcer slowly increases in size and depth. The ulcer is but slightly painful, and does not give the patient much inconvenience. If he lies up and does not walk, the ulcer heals, always with the production around it of a large and unnecessary amount of horny epithelium. If he walks again, the tissue breaks down and the ulcer reappears. From time to time the raw surface becomes infected, and he has an attack of cellulitis of the foot, more or less severe.

As time goes on the condition becomes slowly worse until a joint is opened or a bone infected. Amputation of the toe is then made, the wound heals slowly, but kindly, but when the patient begins to walk again a new ulcer forms in some other place. The entire course of the process may extend over a period of many years.

Trophic Ulcer

A similar condition not infrequently follows the division of large nerve trunks in the leg—trophic ulcer. In these cases the disturbance of nutrition in the limb is more evident. The entire foot may be blue and cold, and there is a tendency to continued desquamation. The muscles supplied by the divided nerve are atrophied. From the pressure of the boot, or from some trifling injury, an ulcer appears upon the sole of the foot, and grows larger and deeper. True gangrene is more apt to occur in these cases than in tabes, and considerable portions of tissue may thus be destroyed. If the patient ceases to walk the raw surface may take on a healthy healing action, but there is always a tendency to recurrence. (See, also, Injuries of Special Nerves.)

Fig. 59.—Deformity of Foot and Ankle Following Severe Burns. (Collection of Dr. C. N. Dowd.)

Decubitus or Bedsore

In the course of acute infectious diseases, following injuries and diseases of the spinal cord, and, in fact, under all conditions where extreme debility renders it necessary for an individual to lie in bed upon his back for a long time, gangrene may occur from impaired nutrition or the continual pressure exerted upon the tissues between the bones of the skeleton and the bed. Beneath the shoulder-blades, along the lower dorsal spine, over the sacrum, the trochanters, and beneath the heel are the places where this form of gangrene occurs. The skin becomes reddened, blebs form upon its surface, the skin beneath becomes necrotic, and an ulcer of a slowly or rapidly progressive character is formed,

which continually extends until the bones beneath are exposed. The edges of the ulcer are red and inflamed, the base consists of yellow stringy or pulpy dead tissue. If pyogenic infection is added the destruction of tissue may be

Fig. 60.—Extensive Bed-sore of the Sacral Region from Caisson Disease. (New York Hospital-Medical Service.)

very rapid, and septic poisoning may destroy the patient's life in a short time. (See, also, Injuries of the Spinal Cord.)

Symmetrical Gangrene—Raynaud's Disease

Symmetrical gangrene is a rare disease, due, it is believed, to disturbances of the vasomotor centers in the central nervous system. The disease is more common in women than in men, and the majority of cases occur before the age of thirty years. Anemia, chlorosis, and a neuropathic constitution seem to be predisposing causes. The gangrene affects the fingers and toes of both sides of the body chiefly, but may attack the nose, the ears, or other parts of the body. The disease occurs in sharply marked attacks. There may be but one attack or several, rarely many. The attacks are sometimes preceded by nervous excitement, sleeplessness, palpitation of the heart, etc. Preceding the occurrence of gangrene, there are usually, but not always, certain peculiar disturbances in the circulation of the affected part. These are, according to Weiss, of three types: First, regional ischemia; second, regional cyanosis; third, regional rubor.

1. **Regional Ischemia.**—Suddenly and without apparent cause one or more fingers or toes become cold, white, shrunken, bloodless, and insensitive. This condition lasts for seconds, minutes, or hours. The circulation then returns, and only a little numbness remains.

2. **Regional Cyanosis.**—The affected parts become suddenly dark red, then blue, then black. They are slightly swollen, cold to the touch, there are sen-

sations of cold and pricking. After a longer or shorter time the circulation gradually returns, and the part resumes its normal appearance.

3. **Regional Rubor.**—Suddenly, as in the other forms, the fingers or toes become red, hot, and turgid with blood. The phenomena disappear as suddenly as they came.

These several forms of vasomotor disturbance may exist simultaneously on different parts or succeed one another in the same part. There follows an attack of gangrene. The gangrene may be absolutely symmetrical—i. e., exactly the same situation on both sides of the body, or only partly so, or there may be but one spot of gangrene. The gangrene usually occurs in the parts previously affected with circulatory disturbances, but may appear elsewhere. The pulp of the end phalanges of the fingers and toes are the places first affected in the majority of cases. The death of the tissues may be confined to the superficial layers of the skin, or spread more deeply to involve the deeper structures, so that an entire phalanx or the whole finger is lost. Dry gangrene is the rule with a sharp line of demarcation. Moist gangrene is more rare. Pyogenic infection is followed by inflammatory complications. The separation of the dead parts is slow; two to four months usually elapses from the beginning of the attack until the stump is healed.

Gangrene of the extremities, following the use of diseased rye for food, *chronic ergotism*, is at present so rare that mere mention is made of it here. The gangrene of leprosy is associated with other definite signs of the disease.

Noma, Cancrum oris—Gangrene of the Vulva, the Umbilicus

Children whose vitality is profoundly depressed by acute or chronic disease, notably scarlet fever and measles, or who suffer from marasmus due to neglect, improper feeding, etc., suffer from gangrene of the mucous membrane of the mouth and of the lips, cheek, tongue, jaw, hard and soft palate, and of the external genitals, vulva, and umbilicus. The gangrene begins as a small superficial slough upon the site of some small ulcer or abrasion of the skin or mucous membrane; very commonly at the red border of the lip or corner of the mouth. The sloughing process extends with great rapidity superficially, and deeply involving the entire thickness of the cheek in a few days. A livid spot appears upon the skin surface, and rapidly takes on a gangrenous character. There is usually an odor of putrid decomposition. The dead parts take on a greenish-black color; beyond the advancing border the tissues are hard, swollen, and infiltrated. Death occurs in the majority of instances in from four days to two weeks. The gangrene may be arrested and recovery take place. Deformities due to loss of substance remain—for example, cicatricial immobility of the jaw.

The general symptoms are those of grave constitutional depression, often without much febrile reaction. The children lie quietly, are stupid, and do not seem to suffer much pain. Death takes place sometimes in coma or in

collapse from septic poisoning; sometimes from hemorrhage from ulceration of an arterial trunk (facial artery). No special microbe has been isolated. Cocci are found in abundance, both staphylococci and streptococci. Gangrene of the vulva begins at the muco-cutaneous junction, and spreads as on the face.

Fig. 61.—Noma, Gangrene of the Vulva in a Little Girl. Death from septicemia. (New York Hospital collection.)

The pubic region, perineum, bladder, and rectum may be involved before death. Gangrene of the umbilicus in infants spreads through the thickness of the abdominal wall.

Hospital Gangrene

A progressive necrosis of tissue occurring as a wound infection in crowded hospitals, military prisons, etc., in time of war and famine before the days of aseptic wound treatment. It is at present so rare that few of the younger generation of surgeons have ever seen it. The disease attacked recent or old wounds, abrasions, or ulcerations. Granulating wounds were most often affected. No complete bacteriological study of the disease has been made. It was probably a mixed infection of pyogenic and putrefactive germs. The disease was characterized by hemorrhages into the granulation tissue covering the wound, and by a rapid breaking down of this tissue into a sloughing mass, often associated with the evolution of stinking gas and putrid decomposition. The necrotic process tended to spread quite rapidly. The constitutional symptoms were those of septic absorption. A large proportion of cases ended fatally. Three forms of the disease are described; they often merged one into the other: (1) The croupous or diphtheritic form; (2) the ulcerating form; (3) the pulpy form. This last the most serious.

1. **The Diphtheritic Form.**—The granulations became gray in color, and soon covered with a superficial necrotic layer (diphtheritic membrane). Hemorrhages occurred into the substance of the granulations, and when the false membrane was removed, ecchymotic foci were seen in a mass of sloughing tissue. The discharge from the wound was at first diminished. Later it became thin and more abundant. The wound edges were swollen, red, tender, and undermined.

2. **The Ulcerating Form.**—More severe than the last. The lesion was similar, but was associated with putrid decomposition of the dead tissues, and a greater tendency to advance insidiously beneath the integument with the formation of burrowing sinuses lined with necrotic tissue. Constitutional depression was marked.

3. **The Pulpy Form.**—The onset of the disease was more sudden, and the constitutional symptoms of septic poisoning more marked. The wound surface became greatly swollen, and was rapidly changed into a pulpy putrefying mass. The gangrene was of a distinctly progressive type, involving all the tissues of the limb. Joints were opened, bones became necrotic, and the coats of arteries were destroyed with the occurrence of secondary hemorrhage. The living tissues were in a state of acute inflammation at the advancing border of the gangrene, and were painful and very sensitive. The progress of the disease was so rapid that a wound might become several times its original size in a day or two. The general symptoms were those of septicemia; repeated chills occurred in many cases; the fever was continuous or remittent; the temperature was often very high (104°–106° F.).

DELIRIUM TREMENS

Delirium tremens is an acute form of delirium which occurs in persons who habitually drink an excessive quantity of alcohol. It may occur at any time of life. An attack may follow: (1) Sudden abstinence from alcohol; (2) a prolonged alcoholic debauch; (3) acute diseases (pneumonia, erysipelas, influenza, etc.); (4) an accidental injury or a surgical operation.

The prodromal stage after an injury may be very short, and may last only twenty-four or forty-eight hours. It is, therefore, wise when a patient presents himself with the intention of having a surgical operation performed and shows marked evidences of a chronic alcoholic habit to postpone the operation, if possible, until he has been without alcohol for a fortnight or more. He must be kept quiet in bed during this time and receive appropriate treatment. As occurring after injuries and surgical operations delirium tremens is a very serious disease. It is notably common after fractures of the leg and thigh, and the mortality in these conditions is high. It is well recognized by all surgeons that chronic alcoholics are bad surgical risks. Delirium tremens may be described as running its course in three stages: First, a prodromal

stage, lasting from a day to several days; second, the stage of active delirium, lasting from two to ten days, and ending in death; or in a third stage, that of convalescence.

The *prodromal stage* is characterized by restlessness, sleeplessness, nervous irritability, and coarse muscular tremor (easily observed by asking the patient to protrude his tongue and hold out his hand with the fingers extended). The patient sweats readily, notably upon the forehead. He is very talkative.

After hours, or a day or more, the *symptoms of active delirium* come on, sometimes gradually, sometimes suddenly. He begins to have hallucinations of sight and hearing; these are nearly always of a disagreeable character; numerous animals are crawling over him or trying to bite him—rats, mice, snakes, monkeys, etc.; "little black men are winding him up in endless coils of wire, which he continually strives to unwind (stereotyped movements)." A large number of persons are conspiring against or are trying to do him harm; an angry crowd is cursing him outside the window. This multitudinous character of these delirious concepts is characteristic. He is never quiet for a moment; an extreme degree of motor excitement exists; he moves about in bed and pulls at the bedclothes or tries to get up. Sometimes he is seized with maniacal frenzy and strives, by rushing aimlessly about, to escape the horrid beings which continually molest him; such is the cause of the fatal leaps from windows, etc., in these cases. Homicidal mania is much more rare.

There may be a rise of temperature, even in uncomplicated cases. If the fever is high—103°–104° F.—it is of unfavorable significance. In many cases the temperature is not elevated. The pulse is rapid and compressible. The skin is cool, often bathed in sweat; cyanosis of the extremities is present in bad cases. The tongue is coated, white at first, later it may become dry and brown. Constipation is the rule; rarely profuse diarrhea. The tendon reflexes are exaggerated. There is frequently marked insensibility to pain. The urine is diminished in quantity, of a high specific gravity, and frequently contains albumen. General clonic convulsions and epileptiform seizures occur in some of the bad cases.

The condition described continues for a variable time, two to ten days, and ends, in bad cases, in exhaustion and death. The patients become comatose, or suddenly go into a state of collapse, or die from some complication—nephritis or pneumonia, for example. Some of them pass into an apathetic condition, gradually merging into coma; in this state they may live many days. At the autopsy, in addition to the other lesions of chronic alcoholism, the meninges of the brain are found thickened and edematous (wet brain). If the patient is to recover, he falls into a deep sleep lasting many hours and awakes convalescent. The acute nervous disturbances and hallucinations have disappeared, and beyond some confusion of mind and a feeling of "empty-headedness," lasting for hours or days, these patients suffer only

from a variable degree of prostration. In some cases one or more delusions may persist for some days; rarely the attack is the beginning of a chronic insanity.

IODOFORM POISONING

The very restricted use of iodoform as a surgical dressing for wounds at the present time renders the occurrence of poisoning by this drug quite rare. Iodoform is capable of causing a violent and obstinate dermatitis when used as a powder or in an ointment upon the skin. In former days I saw many cases of this kind. The lesion was more frequent upon the hands that elsewhere, but often spread far beyond the limits of the area to which the iodoform was applied. With the subjective symptoms of burning and itching, the skin of the fingers and hand would exhibit diffuse swelling and redness, followed by vesication. The early limitation of the eruption to a geometrical area corresponding to the size and shape of the iodoform dressing served to distinguish the condition from septic cellulitis. After the redness had existed for several days the horny layer of the skin became sodden and white, and later separated as a cast of an entire finger or several fingers, leaving a moist, weeping, tender, red surface of true skin beneath. Much pain was complained of, and the lesion was slow to heal and prone to relapses from the application of supposedly nonirritating dressings. General intoxication from the absorption of iodoform through recent wound surfaces was formerly not very uncommon. The symptoms of iodoform poisoning were thus grouped by Schede:

1. High Fever. 2. Fever with gastrointestinal irritation, rapid pulse, and depression of spirits. 3. Very rapid compressible pulse without fever. This is a dangerous form. 4. Very rapid pulse and very high fever. 5. Great depression, collapse, early death. 6. Cerebral symptoms somewhat resembling those indicating meningitis. (McBurney.)

In most cases when iodoform has been used at all extensively upon a wound, whether the patient is suffering from iodoform poisoning or not, iodin may be detected in the urine by shaking the urine in a test-tube with a little commercial nitric acid and chloroform. After shaking, the chloroform settles to the bottom of the test-tube, and if iodin is present acquires a purple color. The starch test for iodin may be used in the following way: A little urine is added to a dilute solution of cooked starch. The addition of a few drops of commercial nitric acid causes in the presence of iodin the characteristic deep-blue coloration.

ORTHOFORM DERMATITIS

A peculiar itching erythema, together with very marked edema of the skin, may follow the local use of orthoform as a dusting powder or dressing for

wounds. When used upon the genitals, the edema of the prepuce and scrotum may reach alarming proportions, and in the absence of a correct interpretation of the condition may lead to confusion in diagnosis. The symptoms of burning and itching are marked; true pain is absent. The skin is moderately reddened. If the use of the drug is stopped the edema slowly subsides after a number of days. Vesication is present in some cases.

CHAPTER VII

TUMORS

DEFINITION AND CLASSIFICATION

The diagnosis of tumors is one of the most important and interesting portions of a proper medical training. The family physician should be as well informed in this matter as the surgeon, because to the former are exhibited the often small and apparently innocent new growths of his patients at a time when a correct diagnosis, followed by prompt treatment, will in many instances result in permanent cure, while an expectant attitude will only too often mean delay until such a tardy moment that treatment is unavailing. No entirely satisfactory definition of the word tumor, as used to designate pathological new growths, can be given; the simple translation into English—a swelling—does not suffice, since many swellings have no relation whatever to new growths. We are, moreover, entirely in the dark in regard to the causation of tumors in general, and in regard to certain kinds of tumors we do not, as yet, certainly know whether they are parasitic diseases or not.

Various definitions have been proposed by pathologists for the word tumor. According to Cornil and Ranvier, a tumor is "any new growth which possesses the tendency to persist or to grow." According to Lüke, "a tumor is an increase in volume through the formation of new tissue which fulfills no physiological purpose." According to Billroth, "a tumor is a new growth which occurs from other causes than the inflammatory new growths, and which shows a growth which is not limited by any definite boundary, but which tends to grow indefinitely." Virchow did not attempt a definition of the word tumor.

The diagnosis of tumors naturally falls under two heads: the *clinical diagnosis* and the *microscopical diagnosis*. Clinically, we distinguish two groups of tumors: the benign and the malignant. Microscopically, tumors are divided according to the character of the tissue composing them; broadly, into epithelial tumors and connective-tissue tumors, or, morphologically, tumors may be classified according to the type of embryonal tissue in which they originate. Thus the epithelial tumors are derived from the outermost and innermost embryonal layers: ectoderm or entoderm, the epiblast and the hypoblast. The connective-tissue tumors, on the other hand, are derived from the middle layer: the mesoblast, mesoderm.

Commonly, tumors are still further classified, according to the particular type of tissue which they contain, into a number of different classes, to be spoken of later. Some of the epithelial tumors are benign and some are malignant, and the same is true of the connective-tissue tumors; and in regard to the individual tumor, this question of benignancy or malignancy is of far greater consequence for the patient and the physician than is the particular kind of tissue of which the tumor is composed. In not a few instances, indeed, it is difficult, and even impossible, to classify a tumor according to the character and arrangement of the tissues composing it, for certain tumors consist of many kinds of tissue, variously arranged, and the character and arrangement may change markedly with the growth of the tumor. Thus, many benign tumors may after a time acquire a malignant character, and, rarely, a malignant tumor may become less malignant or even benign.

A benign tumor is one which has no unfavorable influence *per se* upon the general health of an individual. It may produce disagreeable, and even fatal, symptoms on account of its size or situation; by pressure, for example, on important organs, as, in the interior of the skull, upon the brain, or, in the neck, by pressure upon the trachea; or, on the other hand, it may produce ugly deformities or may interfere mechanically with locomotion. Another important character of benign tumors is that, once removed, they do not return.

The malignant tumors, on the other hand, possess what may be fairly called an infectious character; that is to say, they not only increase in size, but sooner or later infect the entire organism. Their growth takes place not only by an increase in volume, but by growing into—infiltrating, as it is called—and destroying the surrounding tissues, without regard to their character. They also spread in another way; the tumor cells enter the lymphatic circulation, are carried to the neighboring lymphatic glands, and there produce new tumors possessing all the malignant characters of the primary growth. This is especially true of the carcinomata. Moreover, sooner or later the tumor cells enter the blood current, and lodge in distant organs; thus secondary tumors are produced in the liver, in the lungs, in the bones, etc. When a malignant tumor has thus been disseminated throughout the body, the health of the individual is profoundly affected. He becomes pale, weak, and anemic, and falls into the condition known as cancerous cachexia.

Another marked tendency of malignant tumors is to return after they have been removed by operation, either in the scar or close by in the neighboring tissues (*local recurrence*); *regional recurrence* when the new tumors appear in the neighboring lymph nodes, or when their anatomical situation corresponds with site and direction of the lymph channels. When the new tumors appear in distant organs and the tumor elements have been transported, presumably by the blood current, we speak of them as metastatic tumors, or metastases. It often happens that the tissue of a malignant tumor does not possess the vitality

of the normal structures, and these tumors all show a decided tendency to degenerative changes of one sort or another. This results in hemorrhages into the substance of the tumor, to areas of necrosis and fatty degeneration, and, finally, to ulceration of the skin covering the tumor; this ulceration sometimes takes on a gangrenous character; thus blood-vessels may be opened, and dangerous, or even fatal, bleeding may occur. Putrid and pyogenic infections add the symptoms of septic intoxication, usually in a rather chronic form.

OCCURRENCE

In the diagnosis of tumors a hereditary tendency seldom plays an important rôle; it sometimes happens that successive generations of a family suffer from cancerous disease, but such occurrences are the exception. Nor has a hereditary predisposition any important bearing upon the diagnosis of benign new growths. The carcinomata develop during middle life or later in a large proportion of cases; a certain number do, however, occur in young persons, but not before puberty, it is believed. Of seventy cases of cancer of the breast coming under my own observation, the average age was fifty years; the oldest patient was aged seventy-nine, the youngest thirty-one; twelve of the cases were less than forty years of age. The sarcomata may appear at any time of life; sometimes they are congenital, or appear in infancy, and a considerable proportion of them occur during the period of adolescence and early adult life; they are rather rare in old age.

Malignant tumors occasionally follow injury, and they are especially likely to occur upon parts of the body subjected to mechanical irritation, notably if such irritation is kept up over a period of years. This is especially true of the epitheliomata and carcinomata. The lips, tongue, pharynx, lower portion of the esophagus, pyloric end of the stomach, ileocecal junction, and the anus are subjected to more mechanical irritation than other parts of the alimentary canal, and it is in these situations that cancer is prone to occur. Out of forty cases of cancer of the lower lip which have come under my observation, all were males, and all but one had habitually smoked a pipe, and the cancer first appeared upon the part where the pipe rested. Those who work with paraffin acquire a chronic dermatitis of the skin of the hands, sometimes followed by epithelioma. Chimney-sweeper's cancer of the scrotum has long been known. In recent years it has been noted in numerous instances that the chronic dermatitis occurring upon the hands of those who work with the X-rays has been followed by epithelioma. Ancient scars and chronic ulcerations sometimes become the seat of epithelioma. The sarcomata are known to follow injuries of bone in a certain proportion of cases. Dennis relates seven instances of this kind in which sarcoma followed fractures. Out of seventy cases of sarcoma collected by Coley, forty appeared to have a traumatic origin.

DIAGNOSIS

In the diagnosis of tumors it is necessary to exclude, in many instances, certain inflammatory processes, notably syphilis, tuberculosis, and actinomycosis; encapsulated exudates of various kinds, such as chronic abscesses and unabsorbed effusions of blood; certain parasitic diseases—echinococcus and cysticercus; chronic inflammations with condensation of tissue, such as chronic mastitis, periostitis, ruptured aneurisms, etc. Syphilis is to be eliminated by the administration of mercury and of large doses of iodid of potassium, continued for a number of weeks; tuberculosis, by the recognition of tubercle tissue or bacilli in scrapings from a raw surface, and the inoculation of guinea pigs, and by the use of an aspirating needle; actinomycosis, by the recognition of the characteristic granules in scrapings and discharges. In many instances of doubt the aspirating needle furnishes very valuable information, not only as to the character of the fluid withdrawn from a cavity, but also as to the consistence of the mass—bony, calcareous, partly solid, etc. The needle may penetrate a thin lamella of bone and sink into a mass of soft tissue within its interior, thus demonstrating a distinctive process in the medulla, etc.

The **history** of a tumor often furnishes valuable diagnostic aid. A tumor which has existed a long time and has grown slowly and steadily is probably benign. If, after a tumor has grown slowly for a long period, it suddenly takes on a rapid growth, it has probably become malignant. Rapid growth always creates a suspicion of malignancy. Pregnancy and menstruation cause malignant tumors to grow more rapidly; they may have a similar effect upon benign tumors. A characteristic of certain soft sarcomata is that considerable hemorrhages may take place into the interior of the tumor from time to time. Thus a very sudden increase in the size of the tumor occurs; the sign is of bad omen. A ruptured aneurism may produce a condition not very unlike this, and in certain cases may lead to an error in diagnosis.

For example, a man was admitted to the hospital and came under my care; he had suffered for several months from symptoms indicating obstruction of the left ureter; his urine contained pus. The left loin was occupied by a large tumor; from its situation it was thought to be connected with the kidney. The man stated that the tumor had within the past few days greatly increased in size. A probable diagnosis of hemorrhage into a sarcoma of the kidney was made. An incision in the loin showed that the tumor was a large blood clot in the retroperitoneal tissue. The source of the blood clot was a ruptured aneurism of the abdominal aorta.

Pain.—The pain produced by tumors varies greatly both in the benign and malignant forms. Benign tumors may be very painful when they press upon or involve nerve trunks. Thus the neuro-fibromata, fibrous tumors arising from the sheath of a nerve, are often exceedingly painful. Malignant tumors are often not at all painful while they are small. The sarcomata may grow to a large size, and even destroy life, with but little pain. Carcinomata usually

become painful after a time; the pain is described as of a lancinating character. A sense of tightness or drawing is often complained of in cases of advanced cancer of the breast. When a malignant tumor has broken down and ulcerated, there is usually a good deal of pain. When carcinoma has involved the axillary vessels and brachial plexus of nerves and has caused hard edema of the arm, the sufferings of the patient are constant and agonizing.

In examining an individual tumor, a number of physical facts are to be observed. The situation and point of origin of the growth are of interest. The type of tissue found in a tumor resembles more or less closely the tissue from which it originated. Thus, a tumor growing in the subcutaneous tissue will be a fibroma or a lipoma; a tumor growing from bone will contain bony or cartilaginous tissue, or may be a sarcoma. A tumor of a glandular organ will often be an adenoma, an adeno-fibroma, a cyst, or a carcinoma. The size of a tumor may give some hint as to its character. If it be very large, of slow growth, and the general health of the patient remains good, it is almost certainly benign. If large and of rapid growth, it is probably malignant; an accompanying cachexia will usually render the diagnosis of malignant disease certain.

Number.—The fibromata and lipomata and, notably, fibroma molluscum, of the skin are often multiple. Malignant tumors in their early stages are single, with rare exceptions; later on they become multiple. The two pictures are, however, dissimilar. The multiple benign tumors will usually be, roughly, of the same age and size; of the multiple malignant tumors, the primary growth will be older, the secondary younger, and either large or small. The consistence of a tumor may often be an important element in the diagnosis. Nothing is more characteristic than the soft, elastic, semifluctuating consistence of a lipoma or the stony hardness of a scirrhous carcinoma of the breast. A tumor which is hard in one place, soft in another, is composed of several kinds of tissue or has undergone some form of degeneration; such a condition is not infrequent in sarcomata and in tumors of the parotid gland and testis.

Relation of the Tumor to the Surrounding Parts.—Benign tumors have a connective-tissue capsule but loosely attached to the surrounding tissues; hence, they are movable or the tissues can be moved over them. Some sarcomata have also a capsule in their early stage of growth, and may be movable; later they often infiltrate and cease to be so. Carcinomata are always firmly attached to the surrounding parts; they have no capsule, they infiltrate the surrounding tissues from the start, and often have no sharply marked boundaries. Benign tumors usually leave the skin intact and healthy; it may be thinned and stretched, and, if subjected to pressure or mechanical irritation, superficial necrosis may occur, but the cause is manifestly a mechanical one from without.

Malignant Tumors.—Carcinoma especially, and sarcoma in its later stages, infiltrate and involve the skin, causing often ulceration of a progressive character. Before the skin is actually involved it is pale and glossy; dilated cutaneous veins are often visible. But rapidly growing, malignant tumors may pro-

duce marked redness of the skin—so marked that such tumors may be mistaken for an acute inflammatory process. Benign tumors do not infect the lymphatic glands. If a benign tumor becomes infected with pyogenic germs, the lymph glands will sometimes enlarge; they will also be tender and painful. Carcinoma infects the lymph nodes early in the disease; the enlargements are hard, insensitive, and painless. Sarcoma causes infection of lymph glands less often than carcinoma, and the infection takes place late in the disease. The glands become enlarged, but not hard. As is the case with carcinoma, they are painless and insensitive. One of the peculiarities of certain forms of carcinoma is the production of scar tissue; the contraction of this fibrous stroma of the tumor causes puckering and pitting of the overlying skin. The characteristic retraction of the nipple in carcinoma of the breast is a good example of this effect; it is a sign of a good deal of value, even early in the disease. The ulceration of malignant tumors is not confined to the skin. There is a tendency to degenerative changes in the entire tumor mass, and the skin once broken, the degenerative process often advances rapidly. Thus serious and even fatal bleeding may take place from the raw surface of the ulcer from eroded vessels. Septic infection and putrid decomposition of broken-down tumor tissue is exceedingly common in the later stages of carcinoma.

Macroscopic Appearances.—After a tumor is removed from the body an inspection of its cut surface gives valuable aid in diagnosis. A glistening white cut surface, dry and of rather firm consistence, is characteristic of fibroma. A sharply marked boundary, moderately firm, even consistence, pink or grayish-pink in color, surface moist, but not juicy, and a lobulated structure—adenoma, adeno-fibroma. The drier the cut surface of a tumor and the more distinctly it is encapsulated the more likely that it is benign. The only benign tumors having a juicy cut surface are myxoma and certain fibromata. Inequalities in character of the surface, alternating soft and hard spots here and there, are suggestive of malignancy.

The carcinomata often permit one to see their alveolar structure plainly with the naked eye. Upon squeezing the tumor or scraping its cut surface with a knife, a milky, turbid fluid or semifluid material exudes—the so-called "cancer juice," composed of masses of epithelial cells usually in a state of fatty degeneration. From the surface of epitheliomata one can often express the little white spherical masses of concentrically arranged epithelial cells known as epithelial "pearls." The malignant tumors, as already stated, do not possess sharp boundaries, but send prolongations into or infiltrate the surrounding tissues. Sarcomata vary so much that no single description suffices for a typical picture of their appearances. In their earlier stages they may possess a capsule. The cut surface of a fibro-sarcoma varies but little from that of a fibroma. The round-celled variety has a homogeneous white or pale-gray surface; a milky juice exudes on pressure. The tissue resembles bone marrow, sometimes brain, in appearance. The tumor is usually soft and friable. Hemorrhages and all forms of degeneration are common in both round-celled

varieties of sarcoma. The giant-celled sarcoma, one of the less malignant varieties, a common tumor of the lower jaw (epulis), is a firm, hard tumor not differing much in gross appearance from fibroma. The formation of cystic cavities containing greenish, brownish, blood-stained fluid, or actual blood, is very common in rapidly growing sarcomata. Other macroscopic appearances of tumors on section will be found under appropriate headings.

THE DIAGNOSIS OF THE DIFFERENT KINDS OF TUMORS

Connective-tissue Tumors

Lipoma—Fatty Tumor.—The lipomata form large and small, rounded or ovoid, sometimes lobulated, masses in the subcutaneous tissue. They are always tumors of slow growth. They are sometimes firm; or soft, elastic, almost semi-fluctuating tumors. They are movable beneath the normal skin; as they are moved the skin is often puckered a little here and there over the tumor. A sense of crepitation of the fat lobules can sometimes be made out when the tumor is grasped. Lipomata may form diffuse tumors, usually in the neck; occasionally they become pedunculated. Congenital lipoma occurs as a tumor of the lumbar region and buttocks. If pedunculated, it may form a so-called "false tail." Lipoma occurs in certain situations more commonly than in others: the neck, the back, shoulder, the upper and lower extremity. They are rare on the face, rarer still on the scalp. In addition to subcutaneous lipomata, fatty tumor may occur in a variety of situations. They may be cutaneous, subcutaneous, submucous, superitoneal, subfascial, subsynovial (lipoma arborescens). They may develop within the tendon sheaths, in or between the muscles. Fatty tumors are also found in connection with the spinal canal as the remains of a spina bifida, and also, according to Sutton, as intradural growths of fat. Further details in regard to fatty tumors will be found in the chapters on Regional

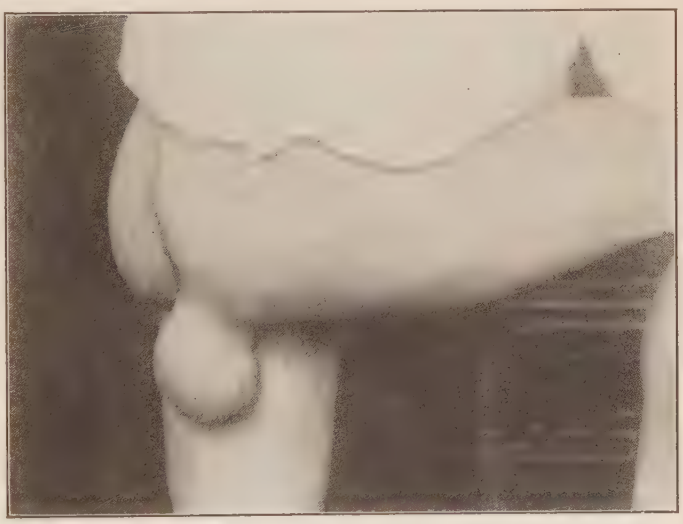


Fig. 62.—Fibro-lipoma of the Buttock.
(Collection of Dr. Charles L. Gibson.)

FIG. 63.—LIPOMA OF THE SHOULDER. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

Surgery. The lipomata occur most commonly during middle life—thirty to fifty years. They are often multiple. They are an entirely benign tumor, but may grow to great size and cause serious symptoms by weight and pressure. Lipoma is sometimes combined with fibroma as fibro-lipoma; the consistence of the tumor is then more firm. Lipoma may undergo various degenerative changes, or may acquire new histological characters and be converted into fibroma, myxoma, and sarcoma.

Fibroma — Fibrous Tumor. — Fibroma consists histologically of bundles of white fibrous connective tissue, arranged sometimes in coarse, waving bands, visible to the naked eye. Sometimes the bundles have a spiral or circular arrangement. The bundles may be closely packed and firm and the consistence of the tumor hard (hard fibroma), or the arrangement may be that of ordinary loosely meshed connective tissue (soft fibroma). The ordinary forms of fibromata are characterized by slight vascularity. Certain combinations of fibroma with lymphangioma and angioma occur that contain numerous dilated blood-vessels of large size, such that their removal may be impossible. The fibromata occur in the skin and subcutaneous tissue, in the sheaths of nerves, in the uterus and ovaries, in the bone and periosteum.

FIG. 64.—MULTIPLE LIPOMATA OF THE BACK OF THE NECK. (New York Hospital, author's collection.)

Fibroma of the skin occurs in two forms: soft fibroma (fibroma molluscum) and hard fibroma (keloid).

Fibroma molluscum.—The tumors are circumscribed or diffuse; they are often multiple and both forms frequently occur in the same individual. The circumscribed tumors are soft, sessile, or pedunculated tumors, varying in size from an eighth of an inch to an inch or more in diameter. They are covered with normal skin. They sometimes occur in large numbers in the same individual, scattered all over the trunk and extremities. The diffuse form causes a peculiar thickening of the skin and subcutaneous tissues such that the skin hangs in loose, soft folds from the face, the scalp, the trunk, or elsewhere (cutis pendula), or very large tumors may be formed, weighing many pounds, hanging from the general integument. The tumors usually grow slowly, and do not at all interfere with the health of the individual. The deformities produced are sometimes extraordinary. In certain cases combinations occur with angioma and lymphangioma; pigmented and hairy tumors are thus produced.

Fig. 65.—Fibroma molluscum. (New York Hospital, service of Dr. Murray.)

Keloid.—A hard fibroma of the skin and subcutaneous tissues. Keloid usually develops in scars or may occur spontaneously. It forms a pink or red, firm, rather flat or slightly elevated, nonvascular mass of dense fibrous tissue. Following burns or wounds, it takes the form of the scar, grows slowly, and sends out prolongations into the surrounding skin. Owing to the feeble blood supply, it is prone to ulcerate from slight traumatisms. After operative removal, keloid recurs almost invariably if undertaken in early or middle life. In old age keloid sometimes undergoes atrophy, and may be removed with a fair chance of cure. Keloid, as well as other forms of fibrous tumor, is more frequent in the negro than in the white race.

Neuro-fibroma—False Neuroma—Tubercula dolorosum.—Fibroma of the hard variety often develops in the connective-tissue sheath or framework of a nerve trunk. The tumors may be single or multiple nodules, rounded, ovoid, or spindle-shaped. They may be situated in or beneath the skin. The subcutaneous variety vary in size from that of a small bean to an inch or more

Fig. 66.—Soft Fibroma of Buttock and Thigh. (New York Hospital, service of Dr. Bolton.)

in length and thickness. In situation they correspond to a nerve trunk, large or small; they are movable, hard, often very sensitive and painful. (See Neuroma.) The tender, painful, bulbous tumors growing on the divided ends of nerve trunks in the stumps of amputated limbs are fibromata, though they sometimes contain nerve fibers of new formation. In the internal organs the commonest example of fibroma is the fibroma of the uterus, occurring usually in

combination with the unstriped muscle fibers of that organ—fibro-myoma. The tumors are single or multiple. They may be submucous, subperitoneal, or intramural; they occur chiefly in the body and near the fundus of the organ, rarely near the cervix, and of any size from that of a pea to that of a fetus at term or larger (see Myoma).

Periosteal Fibroma.—Periosteal fibroma is not uncommon in the nasal fossæ and antrum of Highmore. They are known as fibrous polypi, and may reach a considerable size, obstructing the nasal fossæ and causing deformities of the bones of the face (see Face).

Fibroma occurs in combination with other tumors: fibro-lipoma, fibro-myoma, fibro-sarcoma, fibro-neuroma, fibro-angioma, fibro-lymphangioma.

Fig. 67.—Hard Fibroma of the Lobule of the Ear (Keloid). The formation of keloid tumors is peculiarly common in the African race. In this case it followed perforation of the lobule of the ear made for the insertion of an ear-ring. A similar tumor formed in the lobule of the opposite ear.

Myxoma.—A tumor containing a soft tissue composed of stellate nucleated cells with delicate interlacing processes connecting them with other similar cells embedded in a jellylike stroma having a loose fibrous reticulum. This tissue is embryonal in type, and is found in the umbilical cord. Myxoma occurs as a distinct tumor rarely, but is a common form of degeneration in the connective-tissue tumors, both benign and malignant, notably in fibroma, lipoma, and sarcoma and enchondroma. They are found in the same situations as are fibromata, and in many instances are, no doubt, fibromata which have undergone this form of degeneration. They may be met with in the brain and its membranes. Generally myxomata are benign tumors, but they not rarely become converted into sarcomata, and may form metastases and recur after removal.

Enchondroma—Chondroma.—Tumors of this type are composed of cartilage, usually hyaline cartilage, less commonly fibro-cartilage. Cartilaginous tumors arise in two ways: from cartilage or bone (exchondroma) and from connective tissue (enchondroma). The first class may grow from normal cartilage anywhere in the body. The seats of predilection are the epiphyseal junctions of the long bones, the costochondral junctions, the fingers, the periosteum and

the medulla of bones, the synchondroses. As mixed tumors containing cartilage they occur in the mamma, the parotid gland, the thyroid, the kidney, and the testis. When developed from connective tissue, or from displaced cartilage cells, they occur in the skin and internal organs. They form hard nodular tumors, usually painless and of slow growth. They are often multiple, and may exist in large numbers in the same individual. They usually appear in young persons.

When they grow at the junction of the synovial membrane of a joint with its cartilage (ecchondrosis) they may become detached and form loose bodies,

Fig. 68.—Fibroma Growing in the Soft Parts over the Knee-joint. This tumor had undergone calcification. It was a very hard tumor. (Collection of Dr. Hitzrot.)

or "floating cartilages," so called. These bodies may also arise by the formation of cartilage in the synovial tufts of the joint, becoming detached they also form floating bodies. Such detached chondromata may also be found in the

antrum, frontal sinus, and ethmoidal cells. Chondromata are prone to mucous degeneration, thus cavities and cysts are formed in the tumor. They may undergo ossification, complete or partial. They are usually benign tumors, but may rarely form metastases. The most frequent combinations with other tumors are osteochondromata and chondrosarcomata. The parotid and testicular tumors containing cartilage are often sarcomata or mixed tumors containing a variety of tissue elements.

FIG. 69.—A LIPOMA IN THE POPLITEAL SPACE. A rare situation. The patient was a boy aged thirteen years. The tumor was first observed when he was four years old; and during the year preceding its removal it had doubled in size. (Case of Dr. Ellsworth Eliot.)

Osteoma—Bony Tumors.—Osteomata usually develop from bone or cartilage, but may arise from other tissues by displacement of fetal bony elements or from injury. Thus, bony tumors may be formed in the skin, muscles, tendons and their sheaths, the parotid gland and testis, and even in the brain. They consist of dense bony tissue or of cancellous tissue. Certain bony tumors develop from the periosteum of the skull, which are as hard and dense as ivory; these sometimes grow in the frontal sinus, from the mastoid process and the angle of the jaw. The bony tumors composed of cancellous tissue occur most commonly at the epiphyseal junctions of the long bones; they are covered, while growing, with a layer of cartilage. They may be pedunculated tumors, and may become detached by traumatism. Bony outgrowths of considerable size may occur at the site of fractures. Cavalrymen sometimes develop a bony tumor in the adductor longus muscle. A small bony tumor of cancellous tissue covered by cartilage sometimes develops from the dorsal surface of the terminal phalanx of the great toe in young persons and children; the nail is pushed up in front of the tumor. Some bony tumors growing from the periosteum are movable upon the bone beneath.

A bony outgrowth is usually called an *exostosis*. When developed in the interior of a bone, it is spoken of as an *enostosis*. A bony tumor as it approaches the skin may develop a bursa upon its surface. Sometimes such a bony outgrowth arises from the interior of a joint, and may push the synovial membrane in a pouch before it. This pouch may or may not remain in communication with the joint. Such bursæ contain clear, viscid fluid, and sometimes small loose pieces of hyaline cartilage. A favorite site is beneath the

ligamentum patellæ. This combination of a bony tumor, surmounted by a bursa, has received the name exostosis bursata. The diagnosis of bony tumors is made from their hard consistence, their situation, their frequent attachment to and origin from bone, and their slow growth. As already indicated, they may be sessile or pedunculated, of rounded or irregular contour, even spiny. Under the microscope they exhibit the histological characters of true bone. The X-rays furnish valuable aid in determining the shape, size, and attachments of bony tumors, when not superficial.

Odontoma—Tooth Tumors.—The following description of odontomata is taken from an article on tumors by Dennis, "Dennis's System of Surgery," vol. iv, p. 59:

The tumor takes its origin from a tooth germ; if the tumor arises from the enamel it is termed an epithelial odontoma: if from the fibrous tissue, a fibrous odontoma; if from the tooth follicle, a follicular odontoma: if from the tooth cement, a cementoma; if from the crown of the tooth, a radicular odontoma; if from all the tooth structure, it is termed composite odontoma. The *epithelial odontoma* usually occurs about the twentieth year, and is generally found in connection with the horizontal portion of the inferior maxilla. The tumor is inclosed in a capsule, within which are the multiple and diminutive cysts varying in size and shape and containing a coffee-colored mucoid fluid. The histological structure consists of columns of epithelium which divide and subdivide, and in some cases branches of one column are ingrafted upon that of another. If ulceration occurs in the mucous membrane, the appearance is very similar to epithelioma, for which it must not be mistaken.

The *fibrous odontoma* consists of a tooth contained in its sac, which has become so thickened by the deposit of fibrous tissue that it will not permit the escape of the tooth. In consequence of this environment the development of the tooth is arrested. In the meshes of the fibrous sac chalky concretions are often deposited. This variety of odontoma may be situated in the ramus of the jaw, or in the maxillary portion and project into the antrum, especially in children at the time of the eruption of the second teeth.

The *follicular odontoma* is a tumor occurring between the tenth and twentieth years, and is formed by the union of several denticles. The capsules connect with each other and ossification occurs in the membrane. Thus the union of several denticles forms a compound follicular odontoma, and when one tooth alone is involved a simple follicular odontoma is developed. The latter may involve the permanent teeth, notably the molars. If the wall of the cyst is very attenuated, eggshell crepitation may be present. The cyst contains the tooth surrounded by a viscid fluid. The tooth may be found in its proper position, or may be turned upon its side or inverted. The cysts may be bilateral or they may be multiple. The surgeon should examine to see if the tooth has appeared, as its absence points to the diagnosis of a follicular odontoma, since this variety can only exist in connection with the nonappearance of a tooth or teeth.

Cementoma is a tumor composed of a tooth which is lodged in a hard substance like cementum and surrounded by a capsule, which is not only enlarged but very much thickened by the increase of fibrous tissue. A *radicular odontoma* is a tumor

composed of dentine and cementum, and grows from the roots of the tooth, since in the process of evolution the crown of the tooth is already formed. The *composite odontoma* is composed of the different structures which enter into the formation of a tooth. Usually several tooth germs are united so as to form an irregular mass which bears but little resemblance to a human tooth. The tumor is situated, in about two thirds of the cases, in the ramus of the jaw, and in the other third in the maxilla. If it springs from the upper jaw it may invade the antrum and produce deformity of the face.

The diagnosis of these tumors connected with the teeth is to be made from the youth of the patient; the situation of the tumor; the absence of the ordinary signs of malignancy. A central sarcoma of the giant-celled variety in the lower jaw, where the cortical layer of bone is preserved, although dilated, may lead to confusion even after the tumor is removed; since tissues resembling sarcoma, including giant cells, are often found in growing bone. (For Osteosarcoma, see Sarcoma.)

Angioma.—Tumors containing, or consisting of, abnormally developed blood-vessels. Three forms exist: (1) Angioma simplex; (2) Cavernous angioma; (3) Cirsoid aneurism.

1. Angioma Simplex (*Nevus vasculosus*)—Plexiform Angioma—Telangiectasis (*Birth-mark*).—A flat or slightly elevated tumor, usually of the skin, congenital, or developed during infancy. The tumor is pink, red, or blue in color, according to the preponderance of arteries or veins in its structure, and is sharply circumscribed. It contains numerous capillaries and small vessels arranged in a tortuous manner in the skin. These growths occur with especial frequency upon the face and scalp. The area covered varies in size from a fraction of an inch in diameter to a large portion of the trunk or an extremity. The tumor may remain of the same size or grow in extent slowly or rapidly. Sometimes nevi are covered by a thick growth of hair, resembling the fur of a cat or monkey. Their occurrence is sometimes attributed by mothers to mental impressions during pregnancy. The diagnosis is simple from the foregoing description.

2. Cavernous Angioma.—This tumor occurs in the subcutaneous tissues and in the internal organs, the liver, spleen, and kidney, as well as in the brain and in the bones. The tissue of which these tumors are composed resembles that of the corpus cavernosum penis—that is to say, the blood flows through intercommunicating vascular spaces rather than narrow channels. The vessels and spaces are very much larger than is the case with nevus. The disease is congenital or developed in infancy (except that it may develop in the internal organs of old persons), and tends to increase in size. The skin is normal or blue in color over the tumor; the tumor may pulsate. When compressed with the fingers the blood is readily squeezed out of the vessels, but when the pressure ceases, immediately returns and the tumor resumes its former size. Sometimes these tumors are very large, and, if wounded, serious or fatal bleeding may occur.

3. Cirsoid Aneurism—Aneurysma Racemosum—Angioma Arteriole Racemosum—Aneurism by Anastomosis.—A tumor composed of a congeries of dilated tortuous arteries. The most frequent site is the scalp and face. The branches—namely, of the external carotid artery—and of these, the temporal is most often affected. It occasionally appears upon the hand and fingers. It is more frequent in women than in men, and is a disease

Fig. 70.—Cavernous Angioma, Congenital. The child had an extensive area involving the scalp, the forehead, and the eyelids.

Note.—She was sent to me by Dr. John E. Weeks. The tumor was cauterized by Dr. Charles McBurney in the Roosevelt Hospital. The black area shown in the picture had been cauterized with the actual cautery one week before the picture was taken. No marked improvement could be obtained by this means and I believe the child subsequently died from hemorrhage. (Collection of Dr. Charles McBurney.)

of early life—ten to thirty-five years. The dilated, tortuous, and thickened arteries form a not very prominent tumor; the surface is uneven or wavy, and the boundaries are somewhat irregular in outline. Often large tortuous vessels can be seen or felt running from the periphery toward the central mass. The skin is usually somewhat movable over the vessels beneath, but at points it may be adherent. The tumor is soft and compressible, pulsates distinctly, and a soft murmur may be heard over it upon auscultation. The disease is to be distinguished from an arterio-venous aneurism by the absence of a history of injury, by the fact that the latter disease is of more rapid development and shows a more marked murmur on auscultation and often a thrill. In

arterio-venous aneurism the arteries leading to the central tumor are not dilated, and in this latter affection, if the point of communication between the artery and the vein can be found, pressure upon it will stop the pulsation and the murmur. Angioma sometimes occurs in combination with other forms of tumor, notably with fibroma, lipoma, lymphangioma, and sarcoma.

Lymphangioma.—In these tumors dilated lymph vessels exist as dilated blood-vesels do in the angiomata. They may be divided into three classes:

1. Lymphangioma Simplex or Lymphatic Nevus.—The tumors may occur in various parts of the body. Their most common sites are the skin, the mucous membrane, and the subcutaneous tissues. They are found in the tongue, producing the condition known as *macroglossia*, in which the tongue becomes so much enlarged that it cannot be retained in the mouth. A similar condition occurs in the lips, and produces thickening and deformity—*macrocheilia*. A dilatation and increase in number of lymph vessels, with thickening of their walls, is a part of *elephantiasis*. The neck, the groin, and the axilla are occasional sites. The tumor may be large or small. It is soft and compressible. The dilated lymph vessels may sometimes be felt like a bundle of soft worms beneath the skin. The skin may be normal or pink in color over the tumor. The disease is not attended by pain. If wounded, a lymph fistula may result, with a continuous draining away of a watery fluid, usually clear, sometimes milky.

Fig. 71.—Mixed Venous and Lymphangioma of the Face. A congenital tumor which had very slowly increased in size. Large dilated venous spaces showed blue through the skin of the face. Tumor inoperable. (Collection of Dr. Charles McBurney.)

2. Cavernous Lymphangioma (*Congenital Lymphangiectasis*).—In cavernous lymphangioma the lymph channels are dilated into large spaces by thinning and final disappearance of their walls. The walls of neighboring veins may also give way; the cavities then become filled with blood.

3. Cystic Lymphangioma.—Cystic lymphangioma occurs most often as a congenital tumor of the neck in the submaxillary region. The cyst is sometimes multilocular and of uneven surface, the wall may be thin and the tumor translucent, or thick and dense, resembling the condition of elephantiasis. The cyst may grow slowly or rapidly; in the latter case the tumor may hang down as far as the clavicle, or on the shoulder and extend upward to the zygoma. Severe or even fatal pressure symptoms may be produced in the larynx, trachea, œsophagus. Fluctuation is usually appreciable, but may be obscured on account of the extreme tension of the fluid. Pulsation may be felt where the cyst overlies the vessels. Similar tumors may occur at the back of the neck, beneath the occiput, and in the axilla. These cystic lymphangiomata often become inflamed; after the subsidence of the inflammation cure may follow by atrophic changes in the cyst wall.

Glioma.—These tumors occur in the central nervous system, in the brain, much less often in the spinal cord. They consist of that form of connective tissue which forms the framework of the central nervous system (neuroglia). They are soft or semifluid tumors, usually with imperfectly marked boundaries. According as they are more or less vascular, they are red, grayish-white, or gray in color. They may be so vascular as to resemble angiomata. They do not form metastases. Certain forms of glioma are found to consist of ganglionic nerve cells and newly formed nerve fibers (Ziegler, Klebs, Heller).

Neuroma (see Neuro-fibroma).

Plexiform Neuroma.—A peculiar degenerative change in the sheaths of peripheral nerves such that they become enlarged, thickened, tortuous, and may form a considerable tumor beneath the skin. They commonly occur in conjunction with pigmentation of the skin and the development of hair—in fact, beneath a hairy mole—in some cases without these accompaniments. The tumor may involve the trunk of one or several nerves. The mass of convoluted nerves resembles in appearance a bunch of white worms with bulbous enlargements here and there on individual trunks. In many cases the sheaths of the nerves have undergone mucous degeneration, and may be almost translucent. They are almost confined to the subcutaneous tissues, and occur in various situations. According to Bruns, in forty cases the tumor occurred fifteen times on the temples and upper eyelid; eight times in the back part of the neck; three times on the nose and cheek; four times beneath the jaw and front part of the neck; seven times on the breast and back, and three times on the extremities (Tillmanns). In two cases which I have seen one formed a slightly rounded bulging tumor four inches in diameter in the dorsal region of the back to one side of the middle line. The tumor was soft, almost fluctuating, and thought before operation a lipoma. In the second case a soft, bulging mass could be seen and felt in the submaxillary region extending well down to the clavicle. (Case of Dr. Robert Abbe. See Tumors of the Neck.) Both cases were in children. In neither was pigmentation or hairiness present.

Plexiform neuromata may form tumors of considerable size; they are not

malignant, and are not usually painful. True neuromata—that is, tumors made up in part of newly formed nerve elements—are rare. They may, however, occur in the trunks of the peripheral nerves as tumors formed of medullated or nonmedullated nerve fibers, and may form tumors of considerable size. They may be painful. Another form of neuroma containing ganglionic nerve cells, known as *ganglionic neuroma*, is rarely observed in the brain and spinal cord, in the testis and ovary, and in the sympathetic nervous system. These tumors are usually of slow growth and benign, rarely malignant. Fibro-neuromata may undergo sarcomatous degeneration, and primary sarcoma of the nerve trunks also occurs.

Myoma—Muscle Tumor.—Muscle tumor occurs in two forms: The one consists of unstriped muscle fiber, myoma-lævicellulare (leiomyoma), and rhabdo-

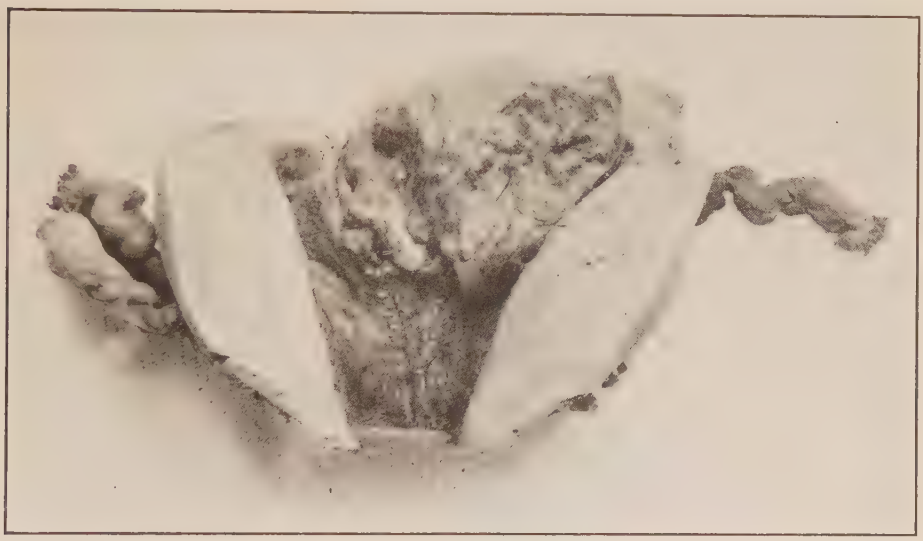


Fig. 72.—Submucous Fibro-myoma of the Uterus. (New York Hospital collection.)

myoma, myoma-strio-cellulare, which consists of muscle of the striped variety. The former is very common, the latter very rare. Myoma of the unstriped variety consists of bundles of unstriped muscular fibers variously arranged and usually combined with a greater or less amount of ordinary fibrous tissue. The muscle cells can be distinguished from the fibrous tissue by their nuclei, their long, spindle shape, and their arrangement in bundles or whorls. They occur most often in the uterus (see Fibro-myoma) and in the muscular coats of the intestinal tract, occasionally from the muscular coat of the blood-vessels. The tumors are nodular and of firm consistence. They are usually of slow growth, but may in time attain an enormous size. Occasionally they grow quite rapidly. Uterine myomata cause various symptoms—bleeding, pressure symptoms upon the bladder, rectum, and uterus, and interference with pregnancy. These tumors are prone to various forms of degeneration—

myxomatous and fatty degeneration, calcification. Cystic cavities may form in their interior. They may slough and die *en masse*, or the necrosis may be localized. Occasionally malignant degeneration may occur.

Fig. 73.—Multiple Fibro-myomata of the Uterus. (New York Hospital, service of Dr. Stimson.)

Rhabdomyoma. — Tumors consisting merely of striped muscular fiber are rare. *Rhabdomyosarcomata* are less so. They occur as congenital tumors in the testis, kidney, and ovary. The muscle fibers exist in combination with other types of tissue. They are often called mixed tumors.

Pseudoleukemia—Hodgkin's Disease — Malignant Lymphoma.—While pseudoleukemia cannot be classed with the true tumor formations, yet, from the clinical diagnostic point of view, it has been thought best to consider it in this

Fig. 74.—Fibro-myoma of the Uterus with Double Hemato-Salpinx. (New York Hospital, service of Dr. F. H. Markoe.)

place. The disease is characterized by progressive enlargement of the lymph nodes throughout the body. By the formation of nodular masses of hyperplastic lymphoid tissue in the lymphatic vessels of various tissues and organs. By enlargement of the spleen, of a variable degree, due to the formation of lymphoid tissue in its substance; usually the spleen is considerably increased in size. By a slowly or rapidly progressive anemia (loss of red cells and of hemoglobin). By a normal or diminished number of leucocytes. (In certain cases and times the white cells may be moderately increased, but the increase does not exceed that found in inflammatory conditions, and never approaches that found in leukemia). In some cases by acute febrile attacks of variable duration. By slow or rapid loss of flesh and strength, and finally by death from tuberculosis or from the local mechanical effects of the masses of lymphoid tissue pressing upon the air passages, etc.; from some intercurrent disease other than tuberculosis; from exhaustion.

Fig. 75. Recurrent Lympho-sarcoma with Multiple Localizations (Hodgkin's Disease). (Collection of Dr. L. W. Hotchkiss, Bellevue Hospital.)

The disease begins by the simultaneous or successive enlargement of lymph glands, usually on one side of the neck; the glands upon the opposite side then enlarge, and the whole chain is affected at once, and often quite suddenly. The axillary, mediastinal, mesenteric, and inguinal glands are successively involved, and masses of new lymphoid tissues later appear in various tissues and organs. Retroperitoneal and mesenteric tumors of this kind may reach a considerable size, and be easily palpable through the abdominal wall. The glands are round, soft, or firm, and movable upon one another and upon the surrounding parts until a late stage in the disease, when they may become fused by periadenitis, rarely by disappearance of their capsules. They are painless and insensitive, and cause inconvenience from deformity and pressure. The individual glands vary in size from that of a pea to that of an apple. The skin remains normal over the tumors.

The growth of the glands and the infection of new sets of glands is not a steady, slowly progressive process. The glands of a region become enlarged to a certain size, and may change but little for weeks or months. Suddenly they begin to grow quite rapidly, new tumors appear in the region already involved, and new sets of glands enlarge in other regions. The glands do not suppurate or break down or become cheesy. There is no tendency to infiltration of the surrounding structures, nor can a continuity of new lymphoid-tissue formation be traced from one set of glands to a neighboring chain; in these two latter traits the disease differs from true lymphosarcoma.

The *histological* structure of the glands cannot be differentiated from an ordinary lymphatic hyperplasia. In the soft form the glands are pink or reddish gray on section, and very soft. *Microscopically* an enormous increase in lymph corpuscles is observed (small and medium-sized lymphocytes, a few polynuclear leucocytes), small giant cells, epithelioid cells, and eosinophile cells. The lymph paths are obliterated in the later stages and in rapidly progressive forms of the disease. The presence of eosinophile cells is regarded by Dietrich and Fischer as of diagnostic importance (Ewing). In the hard form the lymphoid cells are largely replaced by a dense fibrous reticulum. The glands are nearly white on section, smaller, and of firm consistence. Both forms may occur side by side. The hard form is probably an older phase of the process.

Fig. 76.—Diffuse Fibro-lymphangioma of Lower Extremity (Nonparasitic, Elephantiasis). (Medical service, New York Hospital, Dr. Peabody.)

The patients are usually young—ten to forty years of age. In advanced life the disease occurs, but is uncommon. In the more rapid cases there occur from time to time sharp attacks of fever, lasting a few days or a fortnight, or

even longer. The temperature rises gradually, and may reach 104°–105° F. The local conditions remain unchanged. The fever usually subsides suddenly, and the patient may almost resume his ordinary health. During these febrile attacks pure cultures of Staphylococcus pyogenes aureus have been cultivated from the blood and from the substance of the enlarged glands. The condition was not attended by suppuration. Different observers regard the presence of pyogenic germs variously. Ebstein, Pel, and others consider this an essential factor in the disease; Fischer as a mixed infection.

Fig. 77.—Ulcerated and Inoperable Sarcoma of Ribs, Pleura, and Pericardium. Duration of growth nine months only. Female aged twenty-eight. Death from hemorrhage and acute septicemia. (Collection of Dr. F. W. Murray.)

As the disease progresses, emaciation, anemia, anorexia, diarrhea, edema of the extremities, and ascites, cough and dyspnea from pressure upon the trachea or upon the recurrent laryngeal nerves, are added. Fatal dyspnea from pressure by enlarged mediastinal glands may occur before the general condition is seriously impaired. I saw such a case end fatally, while the glands in the neck were only moderately enlarged, and the patient, a youth of eighteen, was still well nourished and in fair general health. Combinations with tuberculosis occur not infrequently in pseudoleukemia. The tuberculosis may be generalized or may affect the enlarged glands. In certain cases, also, transition forms appear to exist between pseudoleukemia and true lymphosarcoma.

Differential Diagnosis.—If tuberculosis is suspected, a gland may be removed, and examined on section with the naked eye and by the microscope for caseous areas, miliary tubercles, hyaline degeneration, and the presence of tubercle bacilli. Guinea pigs may also be inoculated with the suspected tissue. From true leukemia the disease must be differentiated by the marked leucocytosis in the former. From lymphosarcoma by the mode of growth and dissemination characteristic of the sarcomata, and the infiltration of surrounding tissues. Syphilitic infection on the lips or interior of the mouth and throat

is attended by sudden, painless enlargements of the lymph nodes. The primary lesion is usually evident. In inflammatory hyperplasia of lymph nodes some source of external irritation or infection—a carious tooth, a pediculosis capitis, an eczema, a discharge from the ear, etc.—will be noted. Acute inflammatory conditions of the cervical lymphatics follow a focus of infection upon the skin or mucous membrane, or occur in the course of an acute infectious disease. The pain and other signs of pyogenic infection, together with leucocytosis, establish the diagnosis. Secondary carcinomatous and sarcomatous disease of the cervical lymph nodes follow a primary growth usually of a quite evident character. I have seen but two cases of carcinoma of the lymph nodes of the neck in which no primary focus could be found.

FIG. 78.—SARCOMA OF THE SHOULDER-BLADE. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

Sarcoma. — Sarcomata are developed from connective tissue. Histologically they resemble the partly differentiated connective tissues of the embryo. The cellular elements are in excess of the intercellular substance, and the character of the cells is often of an abnormal and aberrant type. Certain types of sarcoma are unquestionably the most deadly forms of malignant disease. In rapidity of growth, in insidious infiltration of surrounding tissues; in precocious dissemination they are unequaled by any form of carcinoma. Their early diagnosis is correspondingly important; unfortunately, it is in many instances correspondingly difficult.

Sarcomata consist of cells of various shapes and sizes embedded in a fibrillary, homogeneous, myxomatous, or reticulated intercellular substance. The cells may be small and round, with a large nucleus and a small amount of cell

protoplasm, or round and large, spindle-shaped, stellate, or the cells may be larger and multinuclear giant cells. In some cases cells of various shapes are found together and in apposition in the same tumor. The blood supply of sarcomata is variable but generally abundant, the vessels are largely capillaries; they may be so numerous that the tumor pulsates, and thus resembles an aneurism; there may even be an audible murmur. The cells of these tumors are in close contact with the caliber of the blood-vessels. Sarcomata possess no lymphatics. These facts serve to explain their dissemination by the veins rather than by the lymph channels. Some forms of sarcoma possess a capsule, and may remain long within it—*central osteosarcoma*; others are infiltrating tumors from the start.

FIG. 79.—MULTIPLE SARCOMATOUS NODULES IN THE SKIN OF THE TRUNK. Inoperable. (Collection of Dr. Charles McBurney.)

Although sarcomata may occur in any part of the body, there are certain seats of predilection—the bones, the periosteum, the subcutaneous tissues, the skin (pigmented moles), the walls of the blood and lymph vessels; certain glandular organs—the parotid gland, the testis, the ovary and the mamma; the brain, the fascia, and the intermuscular planes of connective tissue. They are rarely primary in muscles. The retina and the sheaths of nerves are occasional sites. As noted elsewhere, the various benign connective-tissue tumors may undergo sarcomatous degeneration—fibroma, lipoma, chondroma, etc.—and thus tumors containing mixed elements are formed. The sarcomata themselves undergo various forms of degeneration—mucoid with the formation of cysts, fatty, caseous, calcification, etc.

Owing to the presence of many thin-walled vessels, bleeding often takes place into the substance of the tumor or into the cystic cavities, and the so-called malignant blood cyst is thus formed. When the tumor invades the skin, ulcer-

ation, the formation of large fungating masses of bleeding tissue, and sloughing are common. By growing into the caliber of the veins, tumor cells enter the circulation and find lodgment in the lungs. If the original growth were situated in the portal system the lodgment may take place in the liver. In either case a metastatic tumor results. If the invaded vein is large, considerable tumor masses may break off and plug the pulmonary artery, or be caught in the right auriculo-ventricular orifice.

Fig. 80.—Recurrent Sarcoma of the Back. Inoperable. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

Sarcoma may occur at any period of life; it is common in infancy, youth, and early adult life, but may appear, although less often, in old age. Sarcomata exhibit very varied degrees of malignancy. The more the cellular elements predominate over the intercellular substance the more malignant the tumor. Thus the small, round-celled sarcoma, very rich in cells and poor in stroma, is an exceedingly fatal form. They are soft, rapidly growing tumors which rapidly infiltrate the surrounding tissues and produce early metastases. The pigmented or melanotic sarcoma is also very malignant, and soon disseminates itself throughout the body. The harder forms containing much fibrous tissue and fewer cells (fibro-sarcoma) are some of them almost on the border line of benign new growths. The sarcomata which occur in the medulla of the long bones possess a capsule, and as long as the capsule remains unbroken they may be operated upon and removed with a fair prospect of cure; once the capsule is destroyed and the tumor begins to infiltrate the surrounding tissue, the prognosis is much worse. Sarcomata are classified according to the type of cells they contain and the relations of the cells to the intercellular substance. Combinations of the various types are not uncommon.

Small Round-celled Sarcoma.—As already noted, small round-celled sarcoma is one of the most surely and rapidly fatal forms of malignant disease. It is characterized by rapid growth and infiltration of the surrounding tissues, early dissemination through the veins, and the formation of metastases in the

lungs, liver, kidneys, and elsewhere. The tumor is soft, very vascular; its cut section is white, and resembles brain tissue in appearance. When squeezed, a milky white juice can be expressed from its surface. *Microscopically*, it consists of a fine reticular, granular, or homogeneous stroma, small in quantity, in which lie embedded innumerable small round cells with a large nucleus and a small quantity of protoplasm. These cells resemble a white blood cell, and some of them show ameboid movements. The blood-vessels are numerous, and their walls so thin as to seem to be formed merely of tumor cells. The cells may be evenly distributed throughout the stroma when the structure resembles that of a lymph gland, or a fibrous stroma containing alveoli of various shapes and sizes, filled with cells, may give the tumor an alveolar character (alveolar sarcoma). The structure may be that, in other words, of carcinoma.

Fig. 81.—Recurrent Sarcoma of the Shoulder, Showing a Characteristic Superficial Nodule of Sarcomatous Tissue which had Undergone Ulceration.

Note.—The case presented itself as a fracture near the upper end of the humerus, the result of very slight violence. Soft crepitation and the formation of a large hematoma in the region of the shoulder and upper arm led to the suspicion of sarcoma. Incision showed the upper third of the humerus infiltrated with sarcomatous tissue. Amputation having been refused the diseased tissues were removed as far as was practicable; but, as shown in the picture, recurrence soon took place and destroyed the patient's life. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

Large Round-celled Sarcomata.—Sarcomata of this type possess large globular, nucleated cells, and a structure similar to the small-celled variety. They are not quite so malignant as the small-celled type, but their mode of growth and the effects produced are quite similar. Round-celled sarcoma originates in many tissues and organs: bone, periosteum, muscles, fascia, tendons, lymph glands, connective tissues generally, the brain, spinal cord, ovary, testis, the eye, and in many other situations. They may occur during any period of life from infancy to old age.

A variety of round-celled sarcoma is known as *lympho-sarcoma*, from the resemblance of their tissue to that of a lymph gland. They occur most often in

young persons, and their favorite situations are said to be the base of the tongue and the larynx, the tonsils, the testes, the superior mediastinum, the subpleural and subperitoneal tissues (Sutton). They do not differ in malignancy from the ordinary small-celled form.

Fig. 82.—Sarcoma of the Skin on the Inner Aspect of the Knee-joint, Ulcerated. Duration of tumor six months. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

Spindle-celled Sarcoma.—The cells are long and slender and fusiform. The amount of protoplasm may be small compared with the size of the nucleus. These cells tend to arrange themselves in parallel bundles, running in various directions, and may be hard to distinguish from fibrous tissue. The presence of numerous large nuclei is suggestive of sarcoma. In other cases the cells possess abundant protoplasm, and may exhibit transverse striations like muscle fibers. Sometimes spindle-celled sarcoma contains an abundant quantity of ordinary white fibrous tissue; the tumor is then known as *fibro-sarcoma*. Many spindle-celled sarcomata contain sarcoma cells of other types—stellate, giant, or other forms of cells—and sometimes pieces of cartilage, bone, or muscle.

"The spindle-celled sarcomata arise especially in periosteum and secreting

Fig. 83.—Sarcoma of Great Toe; Female Patient Aged Fifty-five. Operative cure, subsequent history not known. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

glands, such as the ovary, testis, parotid, kidney, and mamma" (Sutton). They are less malignant than the round-celled variety; they do not grow as rapidly nor do they form metastases at so early a period. Sarcomata containing stellate cells are usually found combined with myxoma and chondroma. The stellate cells are branched, and possess fine intercommunicating processes. They lie in a soft mucoid basement substance. The alveolar sarcoma "is made up of mononuclear and polynuclear cells, as a rule about as large as average pavement epithelial cells, which lie singly or in groups in a fibrous, less often in a homogeneous intermediary substance. A characteristic feature of this variety is that the cells, contrary to carcinoma, are closely united to the connective-tissue stroma, and cannot be easily separated from the fibrous meshes. Although this forms the means of distinguishing the alveolar sarcoma from carcinoma, yet sections of the two tumors under the microscope often present such similar pictures that it is very difficult to recognize one from the other" (Tillmanns).

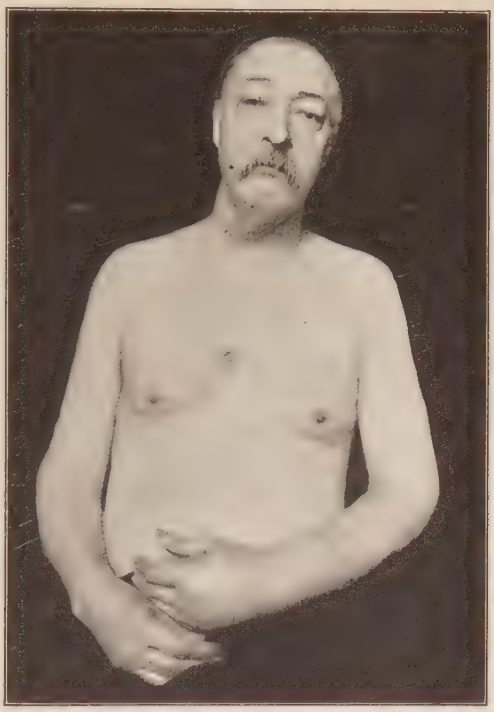


Fig. 84.—Mediastinal Lympho-sarcoma. Dyspnea, dilated veins, edema of arms, widespread metastases. Death from pressure upon the intrathoracic organs. (New York Hospital Medical Service, collection of Dr. L. A. Connor.)

Plexiform Angiosarcoma.—This form of sarcoma originates from sarcomatous degeneration of the walls of the blood and lymph vessels in an angioma. Both the endothelia of the vessel sheath and the endothelia lining the interior of the vessel itself undergo proliferation. By a hyalin degeneration of the walls of the vessels a picture is presented of hyalin cylinders inclosing columns of cells.

If the vessel sheath and the endothelia of the *intima* of the vessel both degenerate, the picture is that of columns of hyalin material inclosed by the undegenerated cells of the sheath. Formerly this peculiar and rather beautiful tumor was known as a *cylindroma*; at present it is spoken of as an *endotheliosarcoma*, or *endothelioma*. These tumors have been especially studied in recent years by Volkmann and by Küster, Manassé, and others. They are sometimes malignant tumors which recur after removal and invade the surrounding tissues through the lymphatics much as do carcinomata; the path from the primary to the secondary tumors can sometimes be traced by the naked eye. They are said to be of fairly frequent occurrence. A peculiarity of the endotheliomata

is that the endothelia of the vessels may undergo degeneration before any appreciable tumor is formed. Such degeneration may lead to the formation of a hematoma; following this there may develop a rapidly growing and malignant sarcoma. These tumors occur most often in the kidney, sometimes in the pleura or lung, and occasionally in other situations. They are believed to arise more often from the endothelia of the lymph vessels, sometimes from the outer layer of the vascular sheaths of the blood-vessels, rarely from the endothelia lining the blood-vessels. They occur partly as distinct tumors and partly in combination with various forms of sarcoma. Some of these tumors remain encapsulated, and are only moderately malignant, or even benign; others run a course closely resembling that of carcinoma, as already noted.

FIG. 85.—RECURRENT SARCOMA OF UPPER JAW AND ORBIT. Inoperable. Four operations were done on this case, but the tumor always returned and finally ended the patient's life. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

A peculiar form of endothelioma is known as *xanthoma*. It occurs as flat or rounded nodules in the skin, sometimes single and sometimes multiple, and characterized by a peculiar sulphur-yellow color due to a deposit of fat in the cells. It is prone to appear where folds of skin lie in contact, notably in the axilla, neck, groin, and other situations. The disease is sometimes a complication of diabetes, and it is said that the nodules sometimes undergo sarcomatous degeneration.

MELANO-SARCOMA—PIGMENTED SARCOMA.—This is one of the most malignant forms of tumor. It is characterized by a deposit of pigment of a brown or black color in the tumor cells, sometimes in the intercellular substance. The cells are commonly round, spindle-shaped, or branched. In a good many cases the tumor is of the alveolar type. They frequently originate where pigment already exists, as in pigmented moles. They are characterized by an extraordinarily rapid dissemination to distant parts of the body. The pigmented spot upon the skin becomes larger, and begins to form a tumor which rapidly increases in size. In some cases, before the original growth has attracted serious attention dissemination has already occurred. The favorite sites for the development of melano-sarcoma are beneath pigmented moles, notably those which are hairy, beneath the finger nails and toe nails, elsewhere on the extremities, and in the neighborhood of the anus and vulva. They occur also in the choroid coat of the eye, more rarely in the ciliary body. They early infect the neighboring lymphatic glands.

Sometimes the dissemination appears to be more that of some pigment-producing substance than of tumor cells. The urine may be deeply pigmented (melanuria). The urine, when first passed, may be clear, and after a few hours may turn as black as ink. The secondary deposits take place in the skin, producing visible pigmented tumors; in the lungs, in the liver, and, in fact, in any of the tissues. Examination of the bodies of patients dead of this disease may show an extensive deposit of pigment in all the tissues. Pigmented tumors may be found in the internal organs and elsewhere, and the cut surfaces of the solid viscera and of the bones may appear as though they had been rubbed with some dark-brown or black pigment. The disease rarely occurs in childhood, and the greatest number of cases occur during middle life.

Chloroma.—Chloroma is a form of round-celled sarcoma originating usually in the periosteum of the bones of the head and face, and producing secondary nodules in the internal organs by metastases, and characterized by a peculiar pale grass or brownish-green color due to the presence in the cells of the tumor of numerous highly refractive granules which give the chemical reactions of fat.

Fig. 86.—Sarcoma of the Vulva Simulating Hernia. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

General Characters of Sarcoma.—From the preceding statements in regard to the different kinds of sarcoma it is scarcely necessary to repeat that it is in general a terrible and deadly disease. The early diagnosis and operative removal through healthy tissues, and at a distance from the disease, offers the only possible hope of cure. Unfortunately, sarcoma is not in general a painful disease in its early stages, and these tumors may, when situated in positions not easily accessible to sight and touch, entirely escape the notice of the patient until they have existed for some time and have attained a considerable size.

Certain general characters of sarcoma are here recapitulated: Origin in connective tissue. Generally tumors of rapid growth. Early they are encapsulated; later they infiltrate, in the worst forms almost from the start. The softer the consistence of the tumor and the more rapid the growth, the worse the prognosis. Owing to degenerative changes, cyst formation, hemorrhage, and the composite character of the tissues they contain, sarcomata are often of uneven consistence, hard, soft, and fluctuating areas alternating in the same tumor.

Differential Diagnosis between Sarcoma and Carcinoma.—Sarcomata do not tend to involve the skin as early as carcinomata, and enormous sar-

comata may be covered by thinned but unbroken skin. Carcinoma early infects the lymph nodes; sarcoma is disseminated usually through the blood current. Lymphatic infection is present only in the later stages; exceptions occur—melanotic sarcoma. The very vascular forms may pulsate. As long as they remain encapsulated they may be movable on the surrounding tissues. Irregular fever occurs in the rapidly growing forms without ulceration; this is not the case with carcinomata; they do not undergo sclerotic changes of the basement substance, hence the puckered condition of the skin often seen over carcinoma is absent.

Anemia.—No definite data exist whereby a differential diagnosis between carcinoma and sarcoma can be made from blood changes; both are usually attended by diminution of red cells and hemoglobin in their later stages. In the individual cases marked differences occur, owing to complications and accidental conditions. Hemorrhage, mechanical interference with the ingestion and digestion of food, ulceration, and pyogenic infection, or their absence, largely determine the grade of anemia in both forms of tumor. *Leucocytosis* is more regularly present in uncomplicated cases of sarcoma than in carcinoma. The more rapidly growing and malignant forms, small round-celled and melanotic sarcoma, show a higher leucocyte count than others. The polynuclear cells are usually in excess. *Eosinophilia* is believed by Mensser to be a diagnostic sign of value in sarcoma of the medulla of the bones (Ewing). Sarcoma may occur at any time of life, but is frequent in youth. Carcinoma regularly develops during middle life or later; is rare in youth. Sarcoma is often painless in its early stages. Carcinoma is usually accompanied by more or less pain of lancinating character.

The Epithelial Tumors

Epithelial tumors are derived from the outer and inner embryonic layers: epiblast and hypoblast. They originate in skin, mucous membrane, and glandular organs possessing epithelium. They include papilloma, adenoma, carcinoma, and epithelioma.

Papilloma.—Papilloma occurs upon the skin and mucous membranes. The tumor consists of a localized hypertrophy of the normal tissue elements—epithelium, connective tissue, and blood-vessels. There are two varieties to be distinguished: the hard and soft papilloma.

Hard Papilloma (*Verruca*).—*Warts.*—Small, hard elevations, with a smooth or uneven surface; in size varying from a pin's head to a quarter of an inch in diameter; white or pink in color, occasionally pigmented. They consist of a base of fibrous tissue containing blood vessels and surmounted by a variable number of layers of horny epithelium. They occur upon the general integument, most often upon the dorsal surface of the hand and fingers; are often multiple. They are common among children. They are neither painful nor tender, unless irritated mechanically. The papillary outgrowths from the

surface may give the wart a mulberry appearance—vulgarly a "seed wart." They are believed to be inoculable. Hyperplasia of the horny layers of epithelium affects the toe nails in certain instances, usually the great toe nail. The cases I have seen were old women of the laboring classes, often bedridden and dirty; the nails were greatly thickened and elongated, sometimes a half inch thick and two inches in length, often curved upward over the toe (onychoma). Similar horny outgrowths, cutaneous horns, may take place from the general integument of the forehead, trunk, and extremities; rarely they are multiple. These horns may reach several inches in length. They occur chiefly in old people, and may arise from cutaneous atheromata (sebaceous cysts). In young persons a combination with angioma may occur upon the dorsal surfaces of the fingers and toes. The base of a cutaneous horn may be the starting point of epithelioma.

Clavus.—Corns of the hard and soft variety are hyperplasias of the horny layer of the epidermis of the toes or sole of the foot. They usually arise from the continued pressure of a badly fitting boot. They are too well known to require a long description.

Fig. 87.—Very Extensive Soft Papillomata of the Penis, Simulating Malignant Epithelioma. Cured by operation. (Author's collection.)

Soft Papilloma.—*Acuminate Warts.*—These occur usually at the mucocutaneous junctions of the vulva and anus and upon the prepuce. They occur spontaneously or as the result of irritating discharges from the urethra or vulva. They have a framework of soft fibrous tissue, are quite vascular, and are covered by a rather soft, thin epithelium. They are often multiple, sessile, or pedunculated, and may form a cauliflower growth of considerable size. They are pink or red in color, soft, tender, and sensitive. When numerous and large they become macerated in the secretions of the skin, and eroded. They are then bathed in a yellow, creamy discharge of most offensive odor; the eroded surface becomes infected with pyogenic organisms, and may ulcerate.

Under these conditions they may be mistaken for cancer of the penis. I have seen cases in which the papillomatous masses would have filled a teacup. Soft papilloma occurs as a polypoid, soft, or warty tumor upon the mucous membrane of the larynx, cervix uteri, bladder, and rectum, and other mucous membranes. They may undergo malignant degeneration.

Villous Tumor of the Bladder and Pelvis of the Kidney.—This is an interesting form of papilloma. The tumor is common in the bladder, more rare in the kidney. It consists of a delicate, branching growth of slender processes containing a connective-tissue framework of delicate blood-vessels and a thin covering of epithelium. The symptoms produced by these tumors are chiefly pain and bleeding, often of a serious character. They may be diagnosticated by the cystoscope, by the passage of portions of the tumor with the urine, and by the bleeding in the absence of other causes. (See Regional Surgery, Bladder.)

Molluscum contagiosum—Molluscum epitheliale.—A rather uncommon disease, which usually occurs among children in orphan asylums, etc., in epidemics. Solitary cases are not common. The disease affects particularly the scrotum, sometimes the face, and is contagious. Small white, waxy-looking nodules appear in the superficial layers of the skin, varying in size from that of a pea to that of a hazel nut; they slowly increase in size, and may become pedunculated; in the center of the surface of the nodule a small yellow or dark-colored speck can be seen—the opening of a sebaceous follicle. If the tumor is squeezed a mass of caseous material is extruded, containing swollen epithelial cells and bodies, regarded by some authorities as the psorosperms, or coccidia of a fungus—the supposed cause of the affection.

Adenoma.—Glandular tumors having the structure of a secreting gland. They consist of a fibrous stroma, containing tubules and alveoli lined with glandular, cubical, or other epithelium; sometimes they have the structure of an acinous gland. When the stroma is in excess, and the cells are few, the tumor is called a *fibro-adenoma*. Sometimes tubules and acini become greatly dilated from retained secretion with the formation of cystic cavities—cysto-adenoma of breast, cysto-thyroid or bronchocele, multilocular ovarian cyst. Adenomata are generally nodular, encapsulated tumors of firm or soft consistence, movable in the surrounding tissues, of slow growth, and not painful. They are, however, prone to undergo cancerous degeneration; the cells proliferate, invade the stroma, finally perforate the capsule and invade the surrounding tissues, and become adeno-carcinomata. There are forms of adenoma which form metastases, and recur after removal without undergoing this cancerous change; such are the malignant adenomata of the rectum. (See also Tumors of the Thyroid Gland.) Adenomata occur especially in glandular organs—the mamma, the kidney, the liver, the thyroid gland, the respiratory tract, the alimentary canal, the genital organs, ovary, testis, skin (arising from sebaceous glands and sweat glands). They are rare in the submaxillary and sublingual glands, common in the prostate and parotid. They occur in the pituitary body.

As already indicated, adenomata vary greatly in size. In the skin they may be only the size of a pea; in the breast, the size of a fist; in the ovary they may occupy nearly the entire abdominal cavity and weigh many pounds. The greater number of adenomata occur during youth and early adult life. They may, however, occur later, as in the prostate. The adenomata undergo cystic and carcinomatous degeneration. Villous papillomata may form on the walls of the cystic varieties. In large cystic adenomata of the ovary calcareous degeneration is not uncommon. Last year I removed a large tumor of this kind, growing from the ovary, which contained calcareous plaques as large and as thick as a man's hand. The adenomata are usually benign, do not recur after operation nor infect the organism. The *symptoms* are usually mechanical, as pressure upon the brain in adenoma of the pituitary body. Interference with urination in adenoma of the prostate; deformity and pressure symptoms in the thyroid gland, the same in large tumors of the ovary.

FIG. 88.—ADENOMA OF THE BREAST. Observe that the tumor is prominent, has a sharply marked border and that the nipple is not retracted. (Author's collection.)

Carcinoma.—Carcinoma is a tumor originating, like adenoma, in epithelial structures. The general arrangement of the tissue is that of a glandular organ, but imperfectly and abnormally developed. There is a fibrous stroma containing alveoli; the alveoli contain cells of the epithelial type arranged more or less irregularly in groups or masses lining or filling the alveoli; generally the cells depart in size, shape, and arrangement from normal glandular epithelium. They possess, however, an extraordinary power of proliferation. They infiltrate, displace, and destroy the normal tissue elements of the vicinity. This process goes on indefinitely. The tumor cells, moreover, enter the lymph channels, and are carried to and lodge in the lymph nodes, there to multiply and produce new tumors. Eventually tumor cells find their way into the blood current, and thus dissemination throughout the organism results, new tumors are formed in various situations.

Carcinoma also invades the overlying skin and produces ulceration. The

ulcer is of irregular shape. Its edges are hard and adherent to the deeper tissues. The base has an unwholesome appearance, sometimes sloughy, sometimes covered with vascular, fungating masses of tumor tissue. In the softer varieties of carcinoma rich in cells, a fungating bleeding mass of tumor tissue may sprout up above the level of the surrounding skin, and grow with extraordinary rapidity. Degenerative processes regularly occur in carcinomata, notably fatty degeneration of the tumor cells, ending in necrosis and sloughing of the older portions of the growth, while new structures are continually being invaded at the periphery.

Cystic, calcareous, and myxomatous degeneration also occur in carcinoma as well as hemorrhages into the substance of the tumor. The tendency of the connective-tissue stroma of carcinoma to contract as an accompaniment to the atrophy and absorption of the cellular elements of the tumor has already been noted; the characteristic retraction and puckering of the skin covering cancers is thus produced. Cancer is always an infiltrating tumor, its very mode of growth precludes the continued presence of a capsule. Cancer occurs primarily only in tissues containing epithelium; the skin and its accessory sebaceous and sweat glands, mucous membrane, and glandular organs, including the entire gastro-intestinal tract, the mamma, ovary, testis, thyroid, prostate, pancreas, the liver, the biliary passages, the parotid, the mucous glands of the cervix uteri, etc. The production of cancer in places subjected to chronic irritations and in scars and ulcerations (especially tubercular and syphilitic) has already been noted. Cancer may also follow a single traumatism. Benign tumors may undergo cancerous degeneration.

Cancer is inoculable. Experimentally cancer can be inoculated successfully on the body of one already suffering from cancer, for example, from a cancerous breast to the other breast. The mucous membrane of the cheek is sometimes inoculated from cancer of the tongue, etc. Rarely this happens from one individual to another. Cancer of the penis has been observed in the husband of a woman suffering from cancer of the cervix uteri. While it is quite probable that in the near future the parasitic nature of cancer will be demonstrated by isolation and successful inoculation of a cancer germ or fungus, as yet the existence of organisms in cancer cells cannot be said to have a diagnostic significance.

The regular course of carcinoma ends in the death of the individual from dissemination of the tumor, and the production of cancerous cachexia, from hemorrhage, chronic sepsis, and exhaustion, or in other cases from starvation, as when the tumor is so situated that the ingestion or assimilation of food is prevented, cancer of the esophagus, pyloric end of the stomach, intestinal obstruction in cancer of intestine; asphyxia, when the tumor presses upon the trachea, the larynx, or the bronchi, etc. In fact, any and every bodily function necessary to life may be impaired and destroyed in the course of the disease. The duration of life varies from a few months to many years. The softer the tumor, the richer in cells and poorer in fibrous stroma; the

more rapid its growth, the earlier the formation of metastases and the development of fatal lesions. On the other hand, a scirrhous carcinoma of the breast may grow very slowly, and not interfere with the general health for many years. The same is true of certain cancers of the skin (rodent ulcer). Histologically, the tumor tissue bears a likeness to the structures in which it has originated, and this likeness is preserved in the secondary tumors formed, no matter where situated. We are thus able to classify carcinomata and divide them into several types.

The Superficial Form of Epithelioma—Skin Cancer.—This form of cancer originates in skin and in mucous membranes; in the skin, either from the squamous epithelium of the Rete malpighii, or from the glandular organs of the skin, especially the sebaceous glands. The disease originates in mucous membranes covered by stratified epithelium, the mouth, the esophagus, the bladder, the vagina, etc.

Fig. 89.—Rodent Ulcer, Slowly Growing Form of Epithelioma of the Skin of the Neck Below the Ear. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

There is a very chronic form of epithelioma originating, according to some observers, in the epithelium of the Rete malpighii; by others believed to grow from the glandular structures of the skin—the sebaceous glands, the sweat glands, the hair follicles, etc., and commonly known as *rodent ulcer*, formerly as *cancroid*. It is characterized by a very chronic course extending over years, and greatly delayed, or absence of constitutional infection. The lymph glands may remain unaffected throughout the disease. It affects the skin of the face in old people, but has been observed as early as the twenty-fifth year. It begins upon the cheeks, the alæ of the nose, the eyelids, the forehead, the ears, the scalp, or the neck. It may begin in a wart, upon the site of a chronic eczema, or originate de novo as a firm rounded nodule, or a flat indurated plaque in the thickness of the skin. A scab usually forms upon the surface, which falls from time to time, and finally leaves behind a superficial ulcer, which bleeds readily. Upon inspection little white points may be noted upon the raw surface. By pressure these may be extruded as minute white spherules or columns, seen under the microscope to consist of masses of laminated epithelial cells, arranged in the spherules concentrically. They are the so-called epithelial "pearls." The ulceration tends to spread

superficially, and does not invade the deeper structures for a long time. This is the form of epithelioma benefited, and sometimes cured, by the X-rays. On section, under the microscope, the tissue is seen to consist of an alveolar fibrous structure. The alveoli contain spherical nests and cylinders of epithelial cells.

Fig. 90.—Epithelioma of the Ankle Growing upon an Old Ulcer. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

Untreated, the disease spreads slowly from the periphery, and sooner or later begins to invade the deeper structures; one after another the features may be slowly eaten away. The eye, the nose, the lips, the cheeks, etc., are destroyed, until the most horrible deformities result. The disease is not necessarily painful, and constitutional infection does not, as a rule, occur. This very chronic form of epithelioma is to be sharply differentiated from the ordinary malignant epithelioma, such as we see so commonly on the lip, penis, and elsewhere.

The Infiltrating Form of Epithelioma.—In this form an indurated nodule appears, which ulcerates, and rapidly infiltrates the surrounding tissues.

Fig. 91.—Epithelioma on the Dorsum of the Hand which Grew in an Old Scar. Excision and skin-grafting. Operative cure. Subsequent history of patient unknown. (Author's collection.)

The edges of the ulcer are hard or elevated; the base is dense and infiltrated; the surface is uneven, bleeds readily; epithelial masses can often be recognized with the naked eye. When such an epithelioma occurs upon a mucous membrane, the surface is often covered with papillary outgrowths elevated above the surface. The lymph nodes soon become indurated and enlarged, and constitutional infection follows. The diagnosis of this form of epithelioma will be more particularly noted in the chapters on Regional Surgery.

Fig. 92.—Epithelioma Developing in the Scar of an Amputation Stump. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

Cylinder-celled Carcinoma—Adeno-carcinoma.—This form of cancer originates in the mucous membrane of the alimentary canal and in the mucous membrane of the uterus. The tumors are soft. The stroma of the tumor is generally small in amount and the cells are abundant. It frequently undergoes myxomatous degeneration.

Fig. 93.—Epithelioma of the Lower Lip. The patient was, as is usual in these cases, a pipe-smoker. The disease had existed for one year. Operative cure. (Author's collection.)

Glandular Cancer—Acinous Carcinoma (Billroth).—This type develops in the several glandular organs of the body—the mamma, the testis, the ovary, the kidneys, the pancreas, the liver, and other glands. The form of the cells and their arrangement vary according to the organ in which the

tumor originates. In the breast, for example, the arrangement of the cells and alveoli resembles, more or less closely, an acinous gland. They form nodular, usually soft tumors, of rapid growth, which frequently break down and ulcerate (glandular cancer).

Carcinoma Simplex.—By carcinoma simplex or tubular cancer we understand a form of cancer in which stroma and cellular elements are both pres-

Fig. 94.—Scirrhous Carcinoma of the Breast. Showing marked retraction of the nipple. (New York Hospital, service of Dr. F. H. Markoe.)

ent in moderate quantity. The alveoli are often small, sometimes long and tubular, sometimes irregular in shape. The cells are round, polygonal, or oval, and have lost their likeness to glandular epithelium. The tumor is generally of firmer consistence than is the case with glandular cancer.

The Carcinomata are further classified according to the relative amounts of stroma and cellular elements, and according to the character of the cells and the appearance of the tumor.

Scirrhus Carcinoma.—This tumor occurs in various situations, most commonly in the female breast. The amount of fibrous stroma is large, the cellular elements relatively few. It is this form which especially produces puckering of the skin and retraction of the nipple. These tumors are characterized by extreme hardness; they feel as hard as a piece of wood. The tissue of the tumor is so hard that it squeaks when cut with a knife. They often cause ulceration of the skin, and become firmly adherent to the surrounding structures. In the breast they generally occur in old women. Sometimes the dissemination is rapid, sometimes very slow. One sees scirrhous carcinomata in the breasts which have existed for many years, without causing general infection. Macroscopically the cut surface is reddish-gray or grayish white in color, and consists mostly of dense connective tissue, with here and there alveoli, containing in the older portions of the tumor epithelial cells, which have undergone fatty degeneration and appear as yellow specks. In the newer parts of the growth the epithelial cells can still be distinguished under the microscope.

Fig. 95.—Carcinoma simplex of the Breast, Ulcerated. (Collection of Dr. Charles McBurney.)

Medullary Carcinoma.—A form of carcinoma containing a large excess of cells and a small amount of fibrous stroma is known as Medullary Carcinoma. The tumor is very soft, the alveoli are very large, and the stroma is thin and delicate. The tumor is exceedingly malignant. The soft tissue composing the tumor bears some resemblance to the medulla of the bones or to brain tissue. The medullary carcinoma sometimes grows very rapidly, forms a knobby soft tumor, which soon ulcerates and forms a fungating mass of bleeding soft-tumor tissue. This is one of the forms of malignant growth to which the name *fungus* hematodes was formerly applied. (See, however, Tumors of the Breast.)

Colloid Cancer—Carcinoma Gelatinosum.—In this form of cancer the fibrous stroma and the cancer cells, one or both, have undergone myxomatous

degeneration. The tumor is composed of soft slimy tissue. It may originate from an ordinary carcinoma which has undergone mucoid degeneration, or from cancerous degeneration of a myxoma. It is rather less malignant than ordinary cancer, and is a rare form. (See Echinococcus Multilocularis, Vol. II.)

Occasionally cancers are observed in which the cells are large and swollen, and sometimes true giant cells may be observed in carcinomata. Occasionally

Fig. 96.—Carcinoma of the Femur and Knee Secondary to Carcinoma of the Uterus. (New York Hospital collection.)

pigment is developed in the cancer cells, and the rare tumor thus formed is known as melano-carcinoma. The diagnosis of the different forms of carcinoma will be more particularly dwelt upon in the chapters on Regional Surgery.

Cystic Tumors

As has already been stated, cystlike formations are common in many forms of tumors, benign and malignant. In addition, there occur cystic tumors of various origins; some of them are true new growths; some of them are due to the retention, in glandular organs or in their ducts, of the secretory products of the gland; some of them are due to the presence in the tissues of abnormally placed fetal structures; some of them are due to inflammatory processes in preëxisting body cavities; they may be due to the growth in the body of various forms of animal parasites. Cystic formations may result from traumatisms; such are the blood cysts formed by collections of blood, hematomata, which are not absorbed.

Cysts Due to True Tumor Formation.—These frequently form in adenomata when the cells lining the tubules undergo rapid proliferation. The ducts become dilated, and their contents undergo degeneration, usually mucoid or colloid degeneration. These tumors are common in the ovary; the multiple proliferating cysts of the ovary are tumors of this character, and may grow to a very large size. The single or multiple cystic tumors of the thyroid gland begin as adenomata, and their degeneration is followed by the production of a cystic tumor. Another variety of cystic tumor occurs in connection with the abnormal development of the teeth, as described under Odontoma. They cause dilatation of the inferior maxillary bone, and may attain a large size. Some of them are true proliferating tumors, and some of them may finally take on a sarcomatous character and recur after removal. Cystic formations also occur in the long bones; some of them are the result of degenerative processes in sarcomata, and arise from myxomatous degeneration of enchondromata, or other connective-tissue tumors. They occur most commonly in the femur.

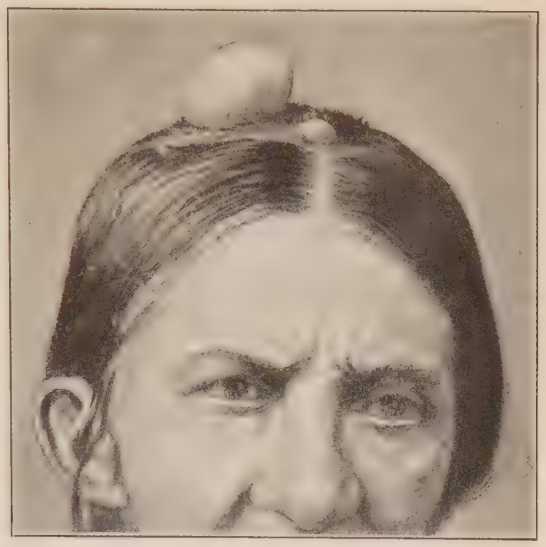


Fig. 97.—Sebaceous Cysts of the Scalp. (Collection of Dr. Charles McBurney.)

Fig. 98.—Rare Congenital Cyst of the Buttock. (New York Hospital, service of Dr. F. W. Murray.)

Retention cysts occur when, for any reason, the duct of a gland is obstructed, so that the secretion of the gland cannot escape. The secretion gradually accumulates, dilates the acini of the gland, or its duct, until a tumor of considerable size may be produced. The walls of the sac are gradually distended, and by pressure the normal tissue of the gland may be gradually destroyed. When such a process takes place in

an important organ, such as the kidney, serious or even fatal results may follow. (See Hydronephrosis.)

Retention cysts may be divided, according to Virchow, into three classes: (1) Mucous cysts; (2) follicular cysts; (3) retention cysts starting in the secretory duct or the acini of the large glands.

1. Mucous Cysts.—Mucous cysts arise from the stoppage of the duct of a mucous gland. They occur wherever mucous glands exist—as in the uterus, the digestive tract, the mouth, the mucous membrane lining the accessory cavities of the nose—notably in the antrum of Highmore.

Fig. 99.—Sebaceous Cyst of the Back of the Neck, Infected. (New York Hospital, service of Dr. F. W. Murray.)

2. Follicular Cysts.—The sebaceous cysts or wens are a common example of this form. They arise from the retained secretion of a sebaceous gland connected with a hair follicle. Such cysts also form in sebaceous glands where no hair exists—as in the corona of the penis and the labium minus. They vary in size from minute dots no larger than a millet seed to tumors as large as a hen's egg, or even larger. When these cysts are of minute size and occur in the duct of the gland, they constitute the so-called *comedones*, or *black heads*, occurring upon the nose or cheeks. When larger they are retention cysts of the gland itself—smooth, rounded tumors beneath the skin. They feel elastic, and are adherent at one point, at least, to the skin, although not to the subcutaneous tissues. Upon minute inspection a little orifice can usually be detected upon the surface of the tumor, from which the contents of the sac can in many instances be expressed. They contain a soft, white, crumbly material, consisting of epithelium, fat, and cholesterin. Sometimes the contents of these cysts undergo partial decomposition, with an offensive odor. They are very commonly situated upon the scalp. They have a fairly thick fibrous wall, which sometimes becomes infected and suppurates. Under such circumstances the cyst may burst externally and produce exuberant granulations. Such an inflamed cyst may be mistaken for epithelioma. Sebaceous cysts are frequently

multiple. There is another variety of sebaceous cyst which occurs, not in the skin but in the subcutaneous tissue; they probably arise from misplaced embryonic cells of the epithelial type; they are regarded by some authorities as true tumors. Sebaceous cysts sometimes become converted into epithelioma. From the base of an inflamed sebaceous cyst there occasionally arises a cutaneous horn. Retention cysts occur not infrequently in the liver, in the kidney, in the Fallopian tube, in the salivary glands, in the tear sac, and in the gall bladder.

3. Retention Cysts.—One of the commonest forms of retention cysts is known as *ranula*; it forms beneath the tongue, on the floor of the mouth, a rounded, translucent tumor, of the size of the end of one's thumb or larger, and is filled with mucus. It arises from the closure of the ducts of the submaxillary, sublingual glands, and of the ducts of the Blandin-Nuhn glands.

Implantation Cysts.—Implantation cysts originate from trauma, usually from punctured wounds, whereby a portion of the epithelial elements of the skin is displaced from its normal connections and implanted in a new situation where the cells proliferate and cause the formation of a cyst. Such cysts have been noted upon the palmar surface of a finger, upon the scalp, in the iris, and in the cornea.

Cysts Due to Congenital Defects.—Certain cysts arise when tubular structures, normal in the fetus, fail to close; they are known as tubular cysts. One

Fig. 100.—Cystic Tumor of the Palmar Surface of the Middle Finger, Following an Injury. Probably an implantation cyst. (Author's case.)

of the common examples is cyst of the urachus, between the urinary bladder and the umbilicus. The opening may remain patent into the bladder or through the umbilicus, or both. Cysts also arise from the vitello intestinal duct, the parovarian tubules, and Gärtner's duct. (See Diseases of the Abdomen.)

Dermoid Cysts.—Dermoid cysts are tumors containing more or less perfectly formed structures, such as normally are only developed from the skin or mucous membrane, and found in localities where such structures do not properly exist. They were divided by J. Bland Sutton into four groups, namely, sequestration dermoids, tubulo dermoids, ovarian dermoids, and dermoid patches (moles).

Sequestration Dermoids.—Sequestration dermoids occur in those places where two skin surfaces have been fused together in the embryo, and develop from portions of epithelial embryonic tissue, pinched off, as it were, in the process. They occur in the middle line of the trunk, posteriorly, from the occiput, down the spine to the perineum, in the penis and scrotum, and up the middle line of the front of the body to the neck. In the face and neck they occur along the lines of the branchial fissures and the fissures of the face. In the face, faults of development may occur, according to Sutton, in three ways: a fissure persists; a fissure may close imperfectly and leave a fistula; a portion of surface epithelium becomes sequestrated and forms a dermoid. These dermoids occur at the root of the nose, upon the scalp, frequently in the neighborhood of the orbit, more often at the outer than at the inner angle. They seldom attain a large size. They consist of a fibrous sac lined with epithelial structures resembling those from which they have developed. They contain oily material, cholesterin, hair, epithelial cells, sebaceous glands. Dermoids in general may contain, in addition to the structures mentioned, teeth, cartilage, bone, and, in rare cases, brain, nerve, and muscle tissue, and sometimes rudimentary extremities. Occasionally the contents of a dermoid consists merely of oily material. Dermoids have been reported containing an eye, and in one case a mammary gland. The hair is usually fine and light brown in color; it may be short and curly, or cases have been reported in which a thick switch of hair existed, in one case five and one half feet in length (Mundé).

Tubulo Dermoids.—Tubulo dermoids occur in embryonic canals, which normally disappear before birth; of these, the branchial clefts, the thyro-glossal duct, and the postanal gut sometimes become the seat of dermoids. For the diagnosis of these conditions, see Regional Surgery.

Ovarian Dermoids.—All the structures already enumerated may occur in ovarian dermoids. They are rather important tumors because they may reach a large size, and sometimes become infected with pyogenic organisms, and thus threaten the life of the patient. They possess the physical peculiarity, on account of the puttylike nature of their contents, that if indented by the examining fingers the indentation may remain for some time. If they contain a large amount of hair, a crepitation may be felt when examining the tumor (Kocher).

Dermoid Patches—Moles.—Moles are congenital pigmented patches upon the skin, and are often hairy. They may be very small, or may involve a considerable portion of the cutaneous surface. They frequently occur upon

the face. Clinically they are important because they not infrequently become the starting point of a sarcoma, sometimes of the melanotic type.

Cholesteatoma.—Cholesteatoma are cysts, sometimes dermoid, sometimes atheromatous cysts, the contents of which are made up of fat and of crystalline plaques of cholesterin. The name "mother-of-pearl" tumor is sometimes used on account of the white, glistening appearance of the cholesterin crystals. They occur in the membranes of the brain, sometimes in the ventricles, in the middle ear, the mastoid process, and the petrous portion of the temporal bone, and in some of the glandular organs, notably in the ovary. They are regarded by some observers as belonging to the endotheliomata. They are benign tumors, but may give rise to dangerous, and even fatal symptoms—in the ear by becoming infected and in the meninges of the brain by pressure.

Psammomata.—These tumors occur in the interior of the skull and in the spinal canal; they are connected with the pia mater of the brain, and sometimes they grow from the choroid plexuses of the ventricles. They are supposed to be related to the endotheliomata. They consist of spherical masses of endothelium or epithelium, surrounded by connective tissue. They often undergo calcification. They lead, if they grow to considerable size, to pressure symptoms of a cerebral or spinal character, according to their situation to headache, and to irritations and palsies of the optic, facial, trigeminal, and auditory nerves. When they affect the motor paths of the brain or spinal cord they lead to progressive paraplegias, ataxia, and other symptoms, ending finally in death.

Fig. 101.—Cystic Dilatation of Both Prepatellar Burs.æ. (New York Hospital, author's case.)

Hydroceles. — These are cystlike tumors containing serum. They occur when a pouch of peritoneum, either normal or due to a hernial protrusion of the peritoneal sac, becomes the seat of a low grade of inflammation or irritation. Such are hydrocele of the tunica vaginalis testis, of the canal of Nuck. Also the serous effusions into hernial sacs, rarely similar effusions between the layers of the great omentum.

Diverticula. — These are dilatation sacs occurring as hernial protrusions from mucous canals. They occur most often in connection with the alimentary canal, from the pharynx, the œsophagus, or the intestine, sometimes from the urinary bladder. Similar protrusions occur congenitally

from the canal of the central nervous system. These latter are known as *neural cysts*. Among them may be mentioned meningocele, cephalocele, hydrencephalocele, spina bifida. A discussion of the diagnosis of these conditions will be found in the chapters on Regional Surgery.

Fig. 102.—Cystic Dilatation of Both Prepatellar Bursæ and of Both Olecranon Bursæ. (New York Hospital, service of Dr. Bolton.)

Bursæ.—Over certain bony prominences, and where muscles and tendons pass over bony points, there exist normally, or are developed as the result of intermittent but chronic mechanical pressure and irritation, thin-walled, fibrous sacs containing clear fluid resembling normal synovia. They sometimes cause pain and inconvenience by becoming inflamed. Such bursæ are developed over the patella (the condition is known as "housemaid's knee"), sometimes beneath the patellar tendon (the ligamentum patellæ), over the tuberosity of the ischium, over the great trochanter, over the olecranon process of the ulna, over the metatarso-phalangeal joint of the great toe, associated with bunion (hallux valgus), over the outer end of the clavicle. These conditions are most often due to occupation or to habit, such that the bursa develops over points exposed frequently to mechanical pressure. Further details will be found under the head of Regional Surgery.

Parasitic Cysts.—Echinococcus (Hydatid Cyst).—The variety of tapeworm known as Tænia echinococcus inhabits the intestine of dogs, wolves, jackals, and allied forms. It is a four-jointed worm, less than a quarter of an inch in length. The first joint is the head. It contains upon the terminal prominence, known as the rostellum, four suckers and numerous hooklets. The fourth, or terminal, joint contains the male and female sexual apparatus, combined in the one individual. The ova contained in the excreta of the affected animal, and swallowed by man through contaminated water or food, are taken

up by the lymph and blood-vessels of the intestine, and are carried by the portal circulation to the liver, where they lodge and frequently develop. Echinococcus is a rare disease in America. It occurs with the greatest frequency in those countries where the people live in close contact with numerous dogs—notably in Iceland, and in sheep-raising countries like Australia; on the Continent of Europe it is not a very common disease.

The liver is the most frequent seat of the disease; the lung, the kidneys, the spleen, the brain, the bones may, however, be the seat of the infection. Wherever the embryos lodge they set up an irritation of the tissues, and a fibrous envelope forms about the embryo; within this envelope the cyst develops. It is described as having two walls—an external one formed of elastic tissue and quite vascular, and an internal one, known as the endocyst, or parenchymatous layer, from the surface of which the so-called brood capsules develop, and in these the little echinococcus heads or scolices are formed. These have a so-called rostellum, armed with a double row of hooklets and four suckers. The capsule enlarges, forming a cyst. The cyst may remain single, or new cysts may develop, either within or without the wall of the parent cyst; and again, from the wall of these so-called "daughter cysts" other cysts may form. The tumors thus produced in the liver are often of considerable size; for example, they may hold several quarts of fluid. The cysts contain usually a clear, light, straw-colored, watery fluid, of a specific gravity of 1.005, and alkaline in reaction. Albumen is usually absent, unless, as is sometimes the case, hemorrhage has taken place into the cavity; sodium chlorid is present in considerable quantity. In echinococcus of the liver the cysts are said to contain leucin and tyrosin, and those in the kidney uric and oxalic acids. The recognition of the hooklets establishes the diagnosis. The entire scolex is about one fiftieth of an inch in length, and the hooklets are seen under the microscope, singly or in groups, in the fluid withdrawn from the sac.

Many of these cysts attain no great size; their inhabitants die, the fluid contents of the cyst are absorbed, and the remains undergo fatty or calcareous degeneration. In another form of the disease innumerable minute cysts, none of them larger than a pea, are scattered throughout the liver (echinococcus multilocularis). If the cysts grow to considerable size, they may finally rupture into one of the body cavities—if into the peritoneum, they may set up serious or fatal peritonitis; if into the alimentary canal, the hooklets, or even cysts, may be passed per rectum; if into the pelvis of the kidney or the urinary bladder, the characteristic structures may be found in the urine; if into the bronchi, they will be found in the sputum. In the abdomen the cysts form a rounded, tense, smooth, elastic tumor. If one hand is placed upon the cyst while the cyst wall is percussed upon the opposite side, a peculiar vibratory thrill is sometimes felt.

Echinococcus Cyst of Bone.—The disease is usually of the multilocular variety. Out of fifty-two cases quoted by Tillmanns, eleven were in the humerus, eight in the tibia, six in the femur, one in a phalanx, eleven in the

pelvis, and four each in the skull, scapula, and sternum; one in a rib. The tumors are of slow growth, and may exist for years without giving rise to marked symptoms. They may finally become painful, the bone may become enlarged, and the picture presented is that of a central tumor of bone which has broken through, or is about to break through, into the soft parts. The diagnosis may be made by the aspirating needle in some cases. They sometimes cause suppuration and the production of sinuses. The discharged pus contains much cholesterin; there is little or no production of new bone, as is the case with ordinary osteomyelitis, followed by necrosis. As already stated, the cysts are minute, the formation of large cysts in bone being rare. Spontaneous fracture sometimes occurs. For echinococcus of other localizations, see Regional Surgery.

Cysticercus Cellulosæ.—During one of the stages of its existence the Tænia solium, one of the varieties of tapeworm, inhabits, not infrequently, the muscular tissues of the pig. An animal butchered in this condition is known as "measly pork." If such flesh is eaten by human beings in a raw or imperfectly cooked state, the protective covering may be digested, and the worm find its way through the wall of the alimentary canal and by the blood current to various situations in the body—the subcutaneous tissues, the muscles, the brain, the abdominal organs, the eye, and other situations. When they lodge in the brain, the eye, or other important organs, they give rise to more or less marked symptoms of their presence—epilepsy, interference with vision, etc. When situated in the subcutaneous tissues or in muscle, they produce no symptoms save that of their mechanical presence as round or ovoid, hard or elastic, little tumors, varying in size from that of a small bean to that of a hazel nut. They are painless and insensitive, do not increase in size, and, unless they become infected and suppurate, produce no symptoms whatever. The cysts may be few in number or very numerous.

They are to be *differentiated* from Fibroma molluscum from the fact that the latter is situated in or upon the skin; that the skin covering a fibroma is frequently flabby and thin; further, that the fibromata are often pedunculated. The orifices of sebaceous glands are often seen upon the surface of a fibroma. Lipomata and sebaceous cysts are notably softer tumors. The neuro-fibromata are situated along the course of nerve trunks, and are usually painful. They are to be differentiated from sarcomata from the fact that they remain quiescent and do not grow, and that they are movable beneath the skin. From subcutaneous gummata they are to be distinguished from the fact that the latter become adherent to the skin, and finally break down, showing the characteristic signs of late syphilitic ulceration.

When they occur upon the conjunctiva they form small cystic tumors between the conjunctiva and the sclera. They are usually firm, often movable; they may have a fibrous cyst wall, or, on the other hand, the sac may be so thin and translucent that the head of the worm can be seen as a minute white dot. The diagnosis is made certain by finding the hooklets in the extirpated

sac. When they are situated beneath the retina they cause separation of this membrane and disturbances of vision. If the media of the eye remain clear, they can be sometimes recognized with the ophthalmoscope as little bluish cysts in the fundus of the eye. The head of the worm may be recognizable, and the parasite, if alive, may even be seen to move. In the vitreous humor they set up an irritation, and produce cloudiness of that medium. If the head merely projects into the vitreous humor, it may here also be recognized through the ophthalmoscope.

Teratoma

Under this name are included a variety of conditions which depend upon malformations occurring in the embryo. The various forms of double monsters as well as the congenital tumors containing heterogeneous masses of any and every sort of tissue are all included in this class. They are supposed to arise when a double embryo is contained in a single ovum, and when one of the embryos goes on to full development while the other develops incompletely and remains attached to the former as a parasite. The tumors may, as stated, contain every variety of tissue. From the surgical standpoint these tumors are chiefly interesting when they occur in such form and in such situations that they can be removed. Tumors containing a variety of tissues occurring in the ovary and testis belong to the teratomata. They usually remain quiescent during the early years of life, and do not take on an active growth until the period of puberty. The occurrence of teratomata will be spoken of more particularly in the chapters on Regional Surgery.

CHAPTER VIII

FRACTURES AND DISLOCATIONS

FRACTURES

The diagnosis of fractures is to be made partly from objective signs and partly from the history of the case and the subjective symptoms. The difficulties in the recognition of fractures vary greatly; in many instances the presence of a fracture can be recognized at a glance; in others, ordinary methods of examination may entirely fail to enable the surgeon to say whether a fracture exists or not.

Causation of Fractures

Before speaking of the diagnosis of fractures in general, it is necessary to refer briefly to the causes of fracture, and to mention some of the varieties of fracture.

Predisposing Causes.—Many more fractures occur in men than in women, owing to the fact that men are more liable to accidental violence from their mode of life and occupations. In young children fractures are rare. Certain bones, from their shape and position, are more liable to fracture than others—the clavicle from its curved shape, the phalanges of the fingers from their exposed position. In old age a predisposing cause exists in the rarefying change in the bones incident to senility, and fractures are relatively more common in old people.

Active or Determining Causes.—Active or determining causes of fracture are *external violence*—direct or indirect—and *muscular violence*. There exists, also, a class of fractures due to local disease of the bone itself or to general causes, such that fractures occur from degrees of violence insufficient to produce them in healthy subjects; these are known as *spontaneous fractures*, sometimes as *pathological fractures*.

Fractures Due to External Violence—*Direct or Indirect.*—A fracture is said to be due to direct violence when the bone is broken at the point of application of the force to its surface; to indirect violence when the fracture occurs at some other point than that to which the force was applied. A very important practical difference exists between these two classes.

Fractures by Direct Violence.—Such fractures are often accompanied by a wound or contusion of the soft parts; such a wound may communicate

directly with the point of fracture, or the contused tissues may subsequently slough and expose the fractured bone. Such an injury may be slight or of any degree of gravity up to the crushing of all the tissues of the limb. Fractures by direct violence occur most often when some portion of the body being at rest is struck by a moving object—a club, a stone, a bullet, the wheel of a wagon or locomotive, or a moving piece of machinery; less often by falls from a height upon a flat surface (unless the individual strikes some intervening object before reaching the ground, or falls upon his head). If he falls upon his feet or hands indirect fractures usually result—although in such falls upon the feet direct crushing fracture of the os calcis is not uncommon.

Fractures by Indirect Violence.—These fractures occur very often as the result of falls either from a height or a simple fall, as from slipping upon ice, a misstep, etc. The majority of fractures of the long bones occur in this way. The force may act in such a manner that the bone against which the force is applied is broken, or through the medium of other bones the fracture occurs in a distant bone. The bone may be (1) crushed; (2) bent; (3) twisted; (4) torn apart. Examples: 1. Impacted fracture of the neck of the femur from a fall upon the great trochanter. 2. Many fractures of the long bones. 3. Fracture of the bones of the leg when, the foot being firmly held, the whole body is rotated. 4. Fracture of the internal malleolus from abduction of the foot.

Muscular-action Fractures.—Fractures from violent contraction of the muscles occur most often in the patella, the olecranon, occasionally in the humerus. Much more rarely the femur, the bones of the forearm, the leg, the ribs, acromion, and other bones.

Spontaneous and Pathological Fractures.—As the result of hemiplegias, locomotor ataxia, pregnancy, osteomalacia, and prolonged disuse of the limbs from disease of the joints; the bones may undergo a rarefying osteitis similar to, and often in excess of, that which accompanies old age; under such conditions fractures may occur from degrees of violence entirely inadequate to produce them in healthy persons. For example: The femur may break by turning over in bed; or the humerus while raising the hand suddenly to the head; or a fracture of the tibia by a misstep in going downstairs or from a slight blow. These fractures sometimes unite promptly.

Rachitis.—In children who have rachitis the bones are sometimes broken from slight degrees of violence. Union may be delayed. *Sarcoma* and *carcinoma*, primary in the bones, or due to secondary deposits, is not infrequent, and destroys and causes absorption of bony tissue, and may lead to fracture from slight causes. While localization may take place in any bone, the femur is most often affected, the humerus next. No symptoms may precede the fracture, or the bone may have been the seat of considerable pain. Strangely enough, the fractures unite in a small proportion of cases.

Osteomyelitis.—In those cases of suppurative inflammation of the bones attended by necrosis there is usually so large a reproduction of new bone during the separation of the sequestrum that fractures are not at all likely

to occur except as the result of the weakening of the bone by extensive operations for the removal of the sequestrum, or the proper drainage of purulent collections in its neighborhood. Under such circumstances fractures may be produced, either during the operation or soon after, during movements of the limb. Such fractures always heal readily, and need give the surgeon no serious anxiety.

Echinococcus.—The occurrence of spontaneous fracture as the result of bone destruction produced by hydatids of the diaphases of the long bones has already been mentioned.

Syphilis.—Circumscribed or diffuse gummatous infiltration of the shafts of the long bones with absorption or destruction of bone substance may lead to the occurrence of fracture from very slight degrees of violence. Such fractures may be attended by very little pain. The distinctive signs of fracture are present. Under fixation and the use of mercury and iodid of potash the fractures commonly unite readily. Delayed union is sometimes observed.

Intra-uterine and Intrapartum Fractures.—Blows upon or wounds of the abdomen of the mother may produce fractures of the bones of the fetus. Such cases are rare, and it is not possible always at the time of birth to determine whether the fracture was produced *in utero* or during delivery, nor even to state positively whether a fracture exists or merely a deformity due to imperfect ossification, except by means of a skiagraph. Fractures during labor are most often caused by instruments used to deliver the fetus, or by the manipulations made during version, more rarely by pressure against the parturient canal. They possess no special diagnostic interest.

The Varieties of Fracture

Fractures may be classified in various ways according to the relation of the broken bone to injuries of the soft parts. We speak of fractures as *compound* or *simple*. A compound fracture is one in which a wound of the soft parts exists, such that the fracture is in communication with the external air. A simple fracture is one in which no such communication exists. Fractures may be further classified, according to the extent of the injury of the bone, into *incomplete* or *complete*: "1. The incomplete fractures may be divided into (*a*) fissures; (*b*) "green-stick" fractures, bent bones; (*c*) depressions; (*d*) separation of a splinter or of an apophysis. 2. Complete fractures subdivided, according to (*a*) direction and character of the line of the fracture, into transverse, oblique, longitudinal, spiral, toothed or dentate, V-, Y-, or T-shaped, and comminuted; (*b*) seat of the fracture into fracture of the shaft, of the neck, of the upper, middle, or lower third, intercondyloid, separation of epiphysis; and, (*c*) if extending into a joint, intra-articular. 3. Multiple fractures, comprising fractures of two or more nonadjacent bones and two or more fractures of the same bone. 4. Gunshot fractures." (Stimson's classification.)[1]

[1] "A Practical Treatise on Fractures and Dislocations," Lewis A. Stimson. Page 22. Lea Bros. 1900.

Incomplete Fractures.—Fissures.—Fissured fractures are characterized by a crack or fissure in the bone, but which does not extend in such a manner as to produce a separate fragment. It is frequently seen in the bones forming the vault of the skull, and is exceedingly common in the shafts of the long bones as the result of wounds made by steel-covered rifle bullets of small caliber. It cannot be diagnosticated except in compound fractures, and in these its importance depends upon the fact that if a fissure extends into a neighboring joint, it may form an avenue of infection from the fracture into the joint.

Green-stick Fracture—Bent Bone.—In nearly all cases this is a true fracture, which does not, however, involve the entire thickness of the bone. The bone is bent, splintering occurs upon the convex side of the bend, and compression of the bone upon the concave side. This form of fracture occurs in the long bones of children; most often in the bones of the forearm, less frequently in the clavicle, and rarely in other situations. It does not occur in the short bones. Angular deformity exists as the result of this fracture.

Depressions.—Depressions are indentations of the surface of flat or spongy bones produced usually by direct violence.

Separation of a Splinter, or an Apophysis.—As the result of direct violence a fragment may be cut or broken from the surface of a bone. Such injuries are commonly the result of saber cuts and the like. The spongy portions of the long bones, the external table of the skull, are common sites. I saw such an injury (a simple fracture) produced in the following manner: A man was struck by an automobile on the outer surface of his right thigh, his legs were knocked from under him, and his body described a somersault so that, as he fell, his left shoulder struck against the edge of the metal hood covering the engine. A small fragment was chipped off the posterior border of the outer third of the left clavicle. The fracture was simple and the continuity of the shaft was not destroyed.

The Separation of an Apophysis.—This occurs from violent muscular action, or by violent traction upon a ligament, so that a portion of bone is torn away from its attachment to the main portion of the bone. Such a fragment may be small or of considerable size. Examples are fracture of the coracoid process of the scapula, fracture of the olecranon, fracture of the coronoid process of the ulna in backward dislocation of the elbow by muscular action, fracture of the internal malleolus by abduction of the foot in Pott's fracture, and fracture of the external border of the lower end of the tibia, also a frequent accompaniment of the same injury.

Complete Fractures.—Complete fractures are those in which a bone is broken into two or more separate fragments. It is customary to classify these, according to the direction of the line of fracture, into transverse, oblique, longitudinal, spiral, toothed or dentate V-, Y-, or T-shaped, splintered. In order to economize space the details in regard to the diagnosis of the various

types of fracture of the long bones will be dwelt upon more particularly under Regional Surgery. The commonest varieties are the transverse and oblique fractures, as the result of such violence as tends to bend the bone. If the broken surfaces of both fragments are markedly jagged, the fracture is toothed or dentate. Certain varieties—the V-shaped fracture, for example—occur most often in the tibia. The Y- and T-shaped, at the lower end of the humerus and femur, and involve the elbow- and knee-joint respectively. A comminuted fracture is one in which the bone is broken into several fragments. Spiral fractures are produced by twisting strains; the line of fracture pursues a spiral course along the shaft. Longitudinal fractures are those in which the line of fracture crosses the bone, either on a very long slant or is approximately parallel to the long axis of the bone. They are comparatively rare.

The use of the X-rays have enabled us to study fractures in a manner formerly quite impossible in the living subject. We are able in most cases to determine the direction of the lines of fracture, the number of fragments, the character of the displacements, the obstacles to reduction, and further to tell with certainty whether our efforts at reduction have been successful and whether our dressings are efficient.

Separation of Epiphyses.—The epiphyses unite at different ages in different bones. In men, union of all the epiphyses is complete by the end of the twenty-fifth year; in women, at the age of twenty-two. In the young, such separations occur at the upper and lower end of the humerus, at the lower end of the radius, at the lower end of the femur, more rarely in other situations. The diagnosis is usually easily made from the physical signs. It can be made with great ease by means of an X-ray picture. For the diagnosis of separation of the epiphyses and fractures involving joints, see Regional Surgery.

Multiple Fractures.—By this term is meant either that two or more bones are fractured, or that two or more distinct and separate fractures are present in the same bone.

Compound Fractures.—The existence of an external opening in the soft parts communicating with the seat of a fracture adds greatly to the gravity of the injury, unless pyogenic infection is avoided. Compound fractures are produced usually by direct violence. The force which causes the wound of the soft parts also fractures the bone. A certain smaller proportion occur from indirect violence by a continuance of the force pushing the broken end of a bone through the soft parts, thus creating a wound of the skin from within outward. In some cases the fracture, at first simple, is rendered compound by penetration of the skin by a sharp bony fragment as the result of injudicious handling, of efforts on the part of the patient to use the limb, of involuntary muscular spasm, of imperfect retentive apparatus during the struggles of an insane or delirious patient. Finally, by sloughing of the contused parts over the seat of fracture. Compound fractures by direct violence are often, from the character of the violence causing them, among the gravest injuries. Such are the fractures resulting from the passage of a heavy vehicle over the limbs—

a locomotive, a trolley car, or the like. Limbs ground up in the toothed wheels of moving machinery or caught between the buffers of railway cars are cases of compound fracture of such gravity that the mere breaking of the bone is a matter of minor importance. The diagnosis of compound fractures is usually easy, as far as determining the presence of fracture is concerned. To estimate the gravity of the associated injuries of the soft parts is not always so simple. It is well to bear in mind that the size of the opening in the skin bears no necessary relation to the amount of destruction to the subcutaneous tissues, muscles, blood-vessels, etc. It often happens that the wound of the skin is small while the injury to the deeper parts is extensive. If there is a wound of the soft parts in the vicinity of a fracture, even though no direct communication appears to exist between the two, the case should be regarded as a case of compound fracture, and treated accordingly. A large proportion of compound fractures are attended by shock of a grave and even fatal character, owing to associated injuries.

Gunshot Fractures.—In the chapter on Gunshot Wounds, mention has been made of some of the characters of gunshot fractures. The reader is referred to that chapter and to wounds of regions.

The Objective Signs of Fracture

The objective signs of fracture are deformity, abnormal mobility, crepitus, ecchymosis, swelling, the formation of blebs. The subjective symptoms of fracture include pain, tenderness, loss of function, and with these may be included the history of the injury, as related by the patient. The deformity

Fig. 103.—Deformity in Recent Fracture of Radius and Ulna in the Lower Third of the Forearm. (New York Hospital collection.)

following fractures varies greatly. In many instances an obvious bend or angular deflection of a limb renders itself evident to the most casual observer. In other instances the deformity may be absent or slight, or it may occur in such situations that it is very difficult to appreciate. Swelling of the soft parts near a broken bone often takes place very soon after the receipt of the injury, due to effusion of blood from the vessels of the broken bone, periosteum, and injured soft parts. Such swelling may obscure the displacement of the broken bone, or, on the other hand, may lead to an appearance of deformity in the bones themselves where none exists.

FIG. 104.—OLD, VERY OBLIQUE FRACTURE OF THE SHAFT OF THE FEMUR, MARKED LONGITUDINAL DISPLACEMENT, SHOWING GREAT SHORTENING OF THE LIMB. The attempt to overcome the shortening by an open operation and continuous traction was only partly successful. The end result was a gain of less than an inch in the length of the limb. (Author's collection.)

FIG. 105.—FRACTURE OF THE LOWER END OF THE RADIUS. Slight displacement of the lower fragment toward the radial side. (Author's collection.)

Deformity.—Deformity is recognized by inspection, palpation, and mensuration. In order properly to examine a fracture, it is desirable that both sides of the body should be exposed, free from clothing, so that the appearance of the injured limb or part may be compared with that of the sound one. The

limbs should, moreover, be in identical positions with respect to the trunk, and the different portions of each limb in the same relations with respect to one another. Only in this manner can a proper comparison be made. In fractures of the upper extremity the shoulders should be level, the arms abducted to the same extent, the elbows flexed to the same degree, and palms pronated or supinated to the same degree. In fractures of the lower extremity the patient must lie flat on his back and a line drawn through the anterior superior spines of the ilia must be at right angles to the median plane of the trunk, the legs parallel and as near together as possible, the knee- and hip-joints extended.

Fig. 106.—Fracture of the Radius and Ulna. (New York Hospital collection.)

The general contour of the injured limb is often so changed that fracture is at once suspected. The limb may appear bent or shortened, and broader and thicker than normal. The lower fragment may be rotated through gravity or muscular action. A distinct prominence or a depression may be seen where a level surface should exist, or, if the bone be subcutaneous, a marked departure from its normal outline may be quite evident. The whole extremity may be depressed, and fall downward or inward as in some fractures of the clavicle. It goes without saying that a thorough knowledge of the topographical anatomy of the part is indispensable for a proper appreciation and interpretation of the changed relations of bony landmarks on the two sides. The skin may be caught and held by the sharp point of a bony fragment. The attitude of the individual may even be quite characteristic in certain forms of fracture.

Ecchymosis.—Ecchymosis is present after most fractures, but may not appear for several days. It often appears at a point below the seat of fracture—

near the elbow in fractures of the upper part of the humerus, in the foot and ankle in fractures of the leg. In fractures of the forearm and leg large blebs containing clear, pink or bloody serum frequently form upon the skin after the first twenty-four hours. In fractures involving joints a rapid effusion of blood takes place into the joint, and often forms a prominent swelling outlined by the attachments of the joint capsule. This is especially notable in fractures of the patella. The inspection of the limb will show contusions, abrasions, or wounds, so situated that a probable conclusion may be drawn as to whether the fracture was due to direct or indirect violence, and even the probable character of the fracture—transverse, oblique, spiral, comminuted, etc.—may be surmised. A wound communicating with the fracture is visible at once. A pointed fragment of bone may even be seen projecting through the skin.

Fig. 107.—Fracture of the Olecranon Process of the Ulna with Separation. (New York Hospital collection.)

By *palpation*, inequalities in outline of the suspected bone can often be appreciated; the finger may sink into a crevice between the fragments. If much edema exists near the point of fracture it may sometimes be gently pressed away with the fingers, and the thickness of tissue between the surface and the injured bone thus considerably diminished. The presence of extravasated blood will give rise to a peculiar sensation of soft crepitation quite unlike that produced by the grating of bone. By palpation, also, the character of the displacement and the shape of the line of fracture may be made out in those bones which are subcutaneous, notably in the clavicle and in the tibia. In comminuted fractures the number, size, and shape of the fragments may sometimes be more or less perfectly estimated.

Abnormal Mobility.—A point of false motion, as it is called, detected in a bone where such motion does not normally exist, is positive evidence of the

presence of a fracture. In some situations and in complete fractures the recognition of this sign is entirely simple. This is the case with most fractures of the shafts of the long bones. When, however, the fracture is incomplete, impacted, or very deeply placed, or very near a joint, or where one fragment is very small, the sign may be absent, or difficult or impossible to obtain. In bones which are very elastic—the fibula and the ribs, for example—a feeling of mobility due to such elasticity may be mistaken for a fracture.

The *method of examination*, whereby the surgeon seeks to obtain this sign, differs in different bones and situations. The manipulation should be conducted with gentleness in order to avoid inflicting upon the patient unnecessary pain or further injury. The sign is most easily appreciated in fractures of the shaft of the humerus and of the femur. The surgeon grasps the limb near the elbow, or at the knee, respectively, and makes slight lateral movements of the bone, usually the abnormal mobility is appreciated at once. Where two bones exist, as in the forearm and in the leg, and both are fractured at nearly the same level, the sign will again be very easy to obtain by gentle lateral movements of the forearm or leg, respectively. If the bones are broken at different levels, the mobility will be less marked, but will nevertheless be easy to appreciate in most instances by manipulations similar to those described.

Fig. 108.—Fracture of the Tibia and Fibula. (New York Hospital collection.)

If but one bone of the forearm is broken, mobility may generally be detected in the following way: The surgeon grasps the bone between the fingers and the thumbs of either hand, the tips of the fingers being separated an inch or more; he then makes slight lateral motions as though he would move the portions of bone grasped between the fingers of either hand, one upon the other, and this manipulation is carried out throughout the entire length of the bone. If a fracture of the upper portion of the radius is suspected, the

hand grasps the elbow with the thumb upon the head of the radius; with the other hand the surgeon holds the hand or wrist of the patient, and makes gentle movements of pronation and supination. If the head of the radius does not rotate beneath the thumb during these movements, the radius is fractured.

Complete fractures of the shaft of the tibia alone, occurring as it does so commonly by indirect violence at the junction of the middle and lower thirds of the leg, can usually be recognized by simple manipulations. Fracture of the fibula alone may or may not present this sign in an easily recognizable form. The most common point of fracture in the fibula is a short distance above the external malleolus, produced by indirect violence in violent abduction of the foot; mobility can sometimes be recognized by direct pressure at the point of fracture. In other cases the following procedure may be used: The surgeon places his thumb upon the tip of the external malleolus, and with the other hand presses upon the shaft of the bone above its articulation with the astragalus and tibia. The fibula may be felt to rock to an abnormal degree upon the astragalus, so that the upper end of the lower fragment is felt to move outward, or the pressure upon the shaft of the bone is gradually shifted upward upon the leg, and in some cases it will be found that when a certain level is reached the tip of the malleolus no longer moves.

Fig. 109.—Old Fracture of the Patella, Separation of the Fragments. (New York Hospital, service of Dr. Hartley.)

In fractures in the neighborhood of joints—the upper end of the humerus, the upper part of the femur, and the upper part of the tibia—slight rotary movements of the shaft of the bone may be made while one hand grasps the upper end of the bone, above the supposed point of fracture. If the upper end of the bone does not follow the shaft, a fracture is present. This sign, of course, fails in incomplete and impacted fractures; it is sometimes of great value in fractures of the surgical neck of the humerus, where the tuberosities are grasped with the fingers; rotary movements are then made of the humerus by grasping the elbow; if the head of the bone is attached to the shaft the tuberosities may be felt to roll back and forth beneath the fingers. In fractures

of the condyles of the humerus and of the femur, or when a small portion of bone is torn away, as in separation of the greater tuberosity of the humerus, the surgeon strives to grasp the condyle or the tuberosity, as the case may be, and move it in the plane of the fracture upon the shaft of the bone.

Crepitus.—Another positive sign of fracture is the grating sensation felt or sound heard when two fractured bone surfaces are moved one upon the other. In order that this sign shall be present it is not only necessary that the fragments should move freely, but also that no soft tissue should intervene; consequently the sign is absent in impacted fractures, in fractures with longitudinal separation, and in cases where muscles, tendons, or other soft parts intervene. It is most marked in fractures of the shafts of the long bones where great mobility exists, in comminuted fractures, and in general where the other positive signs of fracture are most evident. It may, however, be absent or hard to obtain in oblique fractures with much overriding, for in such cases the soft parts may be interposed; it is of course absent in all incomplete fractures. Usually the sign is elicited by the same manipulations through which the surgeon seeks to recognize abnormal mobility. It is not a sign which should be sought for persistently and by means of extensive and strenuous manipulations, on account of the danger of producing further injury to the soft parts. Occasionally crepitus occurs in the examination of a fracture as a loud, sharp click, distinctly audible to bystanders. More often it is simply a grating sensation felt by the surgeon's fingers; it may be mistaken for, or confounded with, other conditions: the softer grating which accompanies separation of an epiphysis through its cartilage; the grating which occurs in joints whose cartilages are eroded from disease; the crepitation of subcutaneous emphysema accompanying fractures of the ribs or wounds of the pleura and lung; the crepitation of inflamed tendon sheaths occurring when the tendons are moved; the crepitation of a blood clot. A differentiation of these various forms of crepitation, while simple enough in most instances, is possible only to those who have had experience.

Mensuration.—In order to detect the presence of shortening in a limb or an increase in circumference or in diameter, when the fracture involves the articular extremities of certain bones; measurements with a tape or with a pair of calipers are sometimes used. Such measurements are only approximate, and cannot be made with absolute accuracy for several reasons. It is rarely possible to apply them in cases of suspected shortening to the extremities of the fractured bone. They must usually be taken from a bony point upon the trunk to another bony point beyond the seat of fracture. These bony points are always more or less flat or rounded surfaces of bone covered by fat and skin movable upon the bone beneath; sometimes the exact locality of such a prominence is obscured by the swelling of the overlying soft parts.

In the case of the humerus, the tip of the acromion and of the external condyle of the humerus are the points between which the measurements are taken. A similar measurement is taken upon the opposite side of the body and the results compared. It is necessary that the two limbs should be in the

same position relative to the trunk and the glenoid fossa. In the lower extremity the measurements are made from the anterior superior spine of the ilium to the tip of the external malleolus. The spine of the ilium is above and to the outer side of the center of motion at the hip-joint, so that the iliac spine, the center of motion at the hip-joint, and the external malleolus form the apices of the angles of a triangle, and, according as the lower extremity is more or less abducted or adducted, the long side of the triangle—namely, the distance from the anterior superior spine to the external malleolus—will vary in length, being shorter when the thigh is abducted and longer when the thigh is adducted irrespective of whether the length of the lower extremity, the other long side of the triangle—namely, the distance from the center of motion at the hip-joint to the external malleolus—varies or not.

Fig. 110.—Fracture of the Shaft of the Femur in a Female Child Aged Ten. Union with overriding. The periosteal bridges along which ossification has taken place are well shown. In spite of the marked overriding the functional result in this case was fairly good. (X-ray picture by the author.)

Fig. 111. Fracture of the Shaft of the Humerus in a Child, Union with Overriding. Showing periosteal bridge uniting fragments. (X-ray taken by the author six weeks after the fracture occurred.)

Accordingly, in comparing the length of the two limbs, it is necessary that they should be in the same relative position in respect to the pelvis. This may be accomplished as follows: The patient is placed upon his back, upon a level surface, with the limbs extended; a cord or straight-edged stick is laid across the anterior superior spines. Midway between the spines a string is fastened, and extended downward between the feet and at right angles to the stick or string crossing the spines. The internal malleoli are then placed equidistant from the string and close to it; measurement may then be made from the spines to the external malleoli of either side, and then compared. With the utmost precautions, an error of half a centimeter, or even more, is still possible.

Another source of error is based upon the fact that in many persons a degree of asymmetry normally exists in the length of the limbs upon the two sides of the body of which the individual is usually unconscious; this may amount to an inch or more in the lower extremities. A further error is the possible existence of a former fracture, for which inquiries should always be made. In fractures involving the large joints, circumferential measurements of the joints are often rendered inaccurate by the presence of swelling. Increase in the width of a joint is best detected by the use of a pair of calipers such as are employed by obstetricians. Thus the elbow, the knee, the ankle may be measured, and an increase of the width of the joint detected in some fractures of the condyles of the humerus and femur. In Pott's fracture of the ankle with separation of the fibula and tibia, the increase in the width of the joint may be quite marked.

Fig. 112.—Fracture of the Tibia and Fibula, Union with Deformity. X-ray taken by the author one year after the injury was received. The functional result was fair; though the patient still complained of pain in the leg while walking.

Subjective Symptoms

Loss of Function.—The loss of function accompanying fracture, although nearly always present to some degree, varies much. It results from mechanical causes, rarely from injuries to nerve trunks, and is caused or increased in many instances by pain, or the fear of pain. In case of complete fracture of the femur or humerus, loss of function is usually complete; the limb lies, or hangs, as if dead. In some cases of fracture loss of function may be very slight. I have known an intoxicated man to walk up three flights of stairs with a fractured tibia and fibula, from which injury he subsequently died. Prize fighters have been known to continue, and even win, a battle with a fractured ulna. Where two bones exist, as in the forearm and leg, the loss of function, although usually present, may be only partial or slight. Individuals have walked with an impacted fracture of the neck of the femur in many instances. It is to be remembered, also, that other injuries than fractures may produce loss of function.

Pain.—Localized pain and tenderness is present in nearly all cases of fracture; it is sometimes slight in persons who have locomotor ataxia and some other diseases of the central nervous system, and may be obscured by delirium or acute alcoholism. The pain of fracture is elicited by pressure, and upon movement of the fractured bone. Spontaneous pain may be moderate, or even

absent, as long as the part is kept quiet. Pain is elicited by pressure at the point of fracture by crowding the broken surfaces of bone together, or moving them one upon the other. In examining superficial bones, finger pressure may be used at successive points along the bone. When the point of fracture is reached the patient almost always gives evidence of severe pain. The ends of the broken fragments may be crowded together in the long axis of the limb. In fractures of the ribs, pressure upon the sternum often gives rise to pain at the point of fracture. In long, slender, and elastic bones, like the fibula, pressure upon the bone by squeezing the leg may give rise to pain at the fractured point. The patient may be directed to make voluntary movements, and to contract certain sets of muscles while the limb is held in a fixed position. Gentle rotary movements of the limb may be used. Extreme localized pain and tenderness are very valuable signs of fracture, and may be sufficient in themselves to establish the diagnosis.

The History of the Patient and of the Accident.—It often happens that a patient who has suffered a fracture has been so disturbed by fear, pain, and emotional excitement, alcoholism, or the unexpected and unobserved character of the accident, or by the unconsciousness or shock produced by the associated injuries, that he is unable to give any intelligent account of the occurrence. On the other hand, he may be able to describe the accident so that the surgeon may know that the fracture was caused by direct or indirect violence or by muscular action. At the time when a bone is broken the individual may hear or feel a distinct snap. He will often be able to describe changes in the shape or appearance of the limb following the accident, and the degree of loss of function from which he suffers. A history of previous fractures and of predisposing causes to fracture, such as injury or disease of the bones, a preëxistent malignant growth, etc., can be sought for, and sometimes obtained. The diagnosis will, however, in general depend upon the objective findings. If after ordinary methods of examination the diagnosis is still obscure, a general anesthetic may be administered; the diagnosis may then be sometimes verified and the fracture dressing applied while the patient is still unconscious. It is, however, in the obscure and doubtful cases of fracture that the X-rays find their greatest field of usefulness, and the majority of obscure fractures or suspected fractures can be discovered or eliminated, as the case may be, by a radiograph or a series of radiographs, to the satisfaction of the surgeon and the patient.

Complications and Course of Fractures

As the result of fractures, and during their repair, certain general and local complications occur the recognition of which is important. The severity of such complications varies much with the seat and character of the fracture and the general condition of the individual.

Delirium Tremens.—In the alcoholic, delirium tremens is a frequent complication of fractures. The symptoms have already been described in another

chapter. In those who acknowledge a marked alcoholic habit it is probably wise, after fracture, to permit the patient to use alcohol in moderate quantities, because it is generally believed that the total withdrawal of the accustomed stimulant may, in conjunction with the injury, bring on an attack.

Fat Embolism.—Fat may frequently be found in the urine of patients suffering from fracture during the first few days after the accident, either microscopically or as a perceptible film of fat globules floating upon the surface of the urine. It is rare, however, that fat enters the venous circulation from the seat of fracture and reaches the capillaries of the lungs in sufficient quantity to interfere with respiration. The serious and fatal cases which have been reported have occurred in from twenty-four hours to three days, rarely as late as five days, after the accident. The symptoms appear, as a rule, suddenly. They are dyspnea with hurried and labored breathing, paleness, later cyanosis of the skin, the physical signs of edema of the lungs, sometimes Cheyne-Stokes respiration and cough, with an abundant watery, foaming sputum, sometimes tinged with blood. Stupor and coma soon follow, and death occurs usually in less than twenty-four hours. The condition can hardly be mistaken for shock, which follows either immediately upon the injury or in an hour or two.

Embolism of the Lungs.—Embolism of the lungs from the dislodgment of a clot in an injured vein—whence, passing through the right heart, it lodges in the pulmonary artery—is a very rare complication of fracture, and usually results in almost instant death. It seldom occurs until the third week following the fracture.

Septicemia.—Septicemia is common in compound fractures which become infected. It may occur in fractures originally simple which become compound by protrusion of a sharp fragment through the skin; in fractures by direct violence when the overlying skin is so severely contused that it sloughs; very rarely in simple fractures by infection through the blood in the presence of a septic focus elsewhere in the body. Among the most violent and rapidly fatal forms of septic poisoning are those which follow compound fractures with extensive laceration of the soft parts; for example, fracture produced by a load of small shot fired at close range; crushing injuries produced by the wheels of heavy vehicles in which infectious material is ground into the tissues; fractures produced by falls from a height in which the bones protrude, and perhaps enter the ground or are extensively soiled by dirt; such injuries may become infected with the bacillus of malignant edema, the Bacillus aërogenes capsulatus, or with the Streptococcus pyogenes and ordinary saprophytic bacteria.

The signs and symptoms of these infections have already been described under Diseases of Wounds. Suffice it to say, that in severe compound fractures the conditions for the development and spread of these infections are ideal. It is to be remembered that in compound fractures in certain regions air may be introduced into the tissues mechanically and cause the subcutaneous crackling observed on palpation when gas is present in the tissues. In these cases the constitutional symptoms and local signs of septic infection will be wanting.

Injuries of the Blood-vessels.—Compound fractures with extensive injuries to the soft parts are sometimes accompanied by contusion or laceration of large arterial trunks. The diagnosis can sometimes be made by the presence of profuse arterial hemorrhage from the wound. In other cases the crushing and twisting violence may have sufficed to obliterate the lumen of the artery, or to tear it in two. In the first instance the diagnosis may be made by finding the bruised vessel without pulsation, often stretched or twisted in the wound, by coldness of the extremity and absence of pulsation below the point of injury. Hemorrhage may occur later if the artery sloughs, or gangrene of the extremity may supervene. Injury of large arterial trunks is less common in simple fracture. In certain situations it may lead to dangerous or rapidly fatal results. If the bleeding takes place into a large cavity—the peritoneum or the pleura—it may be fatal, although the vessel is not very large.

In fractures of the skull, ruptures of the internal carotid or the middle meningeal are usually attended by rapidly fatal compression of the brain. Contusion of a large artery in an extremity may be followed by thrombosis and gangrene, or by the formation of an aneurism at a later period. If the artery is completely ruptured and bleeds subcutaneously, rapid swelling of the limb and the formation of a more or less well-defined tumor at the point of injury, which pulsates after it has attained a certain size, accompanied by diminution or loss of pulsation distal to the rupture, suffice to make the diagnosis. Pressure upon the veins in these cases may be sufficient to occlude them, and gangrene of the limb results; such gangrene is usually of the moist variety. Rupture of a large vein in simple fractures may sometimes be inferred from the swelling of the limb, and may also result in moist gangrene. The gangrene following fractures, as already indicated, may involve the whole extremity when caused by destruction of the main vessels of the limb or by septic infection.

Gangrene.—One of the most unfortunate accidents, both for the surgeon and his patient, is gangrene of an extremity produced by the improper application of dressings. It may follow the application of a circular plaster dressing to a recent fracture, insufficiently padded or too tightly applied, or the application of a circular constriction of any sort about the limb, an ordinary bandage, or even a piece of sticking plaster. It is more apt to follow constriction over a narrow area than a general constriction of the entire limb. The symptoms are an undue amount of pain, swelling and blueness of the fingers or toes, together with the signs of sluggish circulation in these parts; later, coldness and, if unrelieved, the signs of gangrene. After the application of a fracture dressing such as might possibly cause undue constriction, it is the duty of the surgeon to inspect the limb at frequent intervals during the first forty-eight hours, to examine the fingers and toes with care, and to inquire of the patient as to sensations of pain and constriction.

Localized necrosis of tissue or gangrene may follow injuries of the soft parts by the same violence which produced the fracture, or the pressure of an

unreduced fragment which presses against or has partly penetrated and remains caught in the integument. In cases of contusion and laceration of the skin, in fractures by direct violence the probable area of necrosis may be estimated, as suggested by Stimson, in the following way: The limb is rendered bloodless by an elastic bandage applied as for the performance of a bloodless operation. Those portions of skin which do not share in the general blush which follows the removal of the constriction will probably not survive. This holds good except for portions of skin lying distal to a long transverse wound of the integument. Such areas usually remain pale, although they may still survive.

The occurrence of localized gangrene may be recognized by the dusky red color of the dead tissues which is not changed by pressure, by the signs of more or less acute inflammation in the surrounding skin, and the final change of the dead part to a purple and then to a black color. Such necrosis may be aseptic, in which cause the local signs of inflammation will be slight, the slough will remain dry, and the wound left by its separation clean and free from pus, or, if infected, the dead tissues may or may not emit the odors of putrefaction; the constitutional symptoms of sepsis will usually be marked. Incision or operative removal of the dead tissues will show an accumulation of thin, usually brown or blood-stained pus in the deeper tissues. Careful exploration of the wound is necessary to determine the extent and virulence of the infection.

Ischemic Contractures of the Muscles.—The application of circular constriction to a limb, the seat of fracture, so tight as to seriously interfere with the arterial circulation of the limb but not sufficiently to produce gangrene, may be followed by coagulation of the muscle plasma and degeneration of the muscular fibers. The condition is most common as the result of tight bandaging in fractures of the forearm. The muscles undergo a true rigor mortis. The fingers become stiff and flexed, and cannot be straightened. Depending upon the severity of the constriction and the time of its application, the muscles may undergo complete or partial atrophy, the muscular fibers being replaced by fibrous tissue. The condition appears soon after the bandage or dressing is applied, and is to be recognized by an undue amount of pain and coldness of the fingers. In bad cases the fingers become permanently flexed and rigid and the limb permanently atrophied and useless. In less severe cases some motion may be regained by appropriate treatment.

Tetanus.—A rare complication of compound fractures is tetanus. It follows more frequently compound fractures in those regions most likely to be contaminated with the soil—namely, the hands, the forearms, less commonly the legs and feet. The symptoms are described under Tetanus.

Pneumonia.—Pneumonia is not a very rare complication of fractures in the alcoholic and the aged; more rarely it occurs in healthy adults. It is a very serious complication, and is often fatal. In ordinary cases it comes on a few days after the injury, and is apt to run a violent, and often a fatal, course. The pneumonia may be a broncho-pneumonia or a lobar pneumonia, and will

give the characteristic signs and symptoms. In old persons who suffer from fractures and are confined for some time in bed, and who are feeble, hypostatic congestion of the lungs or a low grade of pneumonia of the dependent portions of the lungs not infrequently precedes a fatal issue. The signs and symptoms of the pneumonia are not usually marked. These patients, after they have been in bed for two or three weeks, gradually become weaker; they may have a little fever; they are often mildly delirious. The signs of pneumonia in the bases of the lungs may be discoverable upon physical examination. They gradually lapse into unconsciousness and die. Fractures of the neck of the femur in old people are often followed after a few weeks by death in this way.

Injuries of the Nerves.—A nerve trunk may be contused, stretched, or torn at the time of a fracture, or may be pressed upon by the edge of a bony fragment or by the formation of callus or new bone, or may be included in the callus. Rupture or severe injury of a nerve may be inferred from the loss of function and sensation in the part supplied by the nerve. Owing to the disuse of the limb after the fracture, such an injury may remain unrecognized for some time. In case the loss of function of the nerve is discovered early, it would be generally unwise to assume that it is destroyed unless positive evidences of such a condition exist. The nerve may be only bruised or stretched, under which circumstances its functions will return. A nerve which is compressed by an edge of bone or by an excessive callus formation, may exhibit total or partial loss of function, or may become the seat of a neuritis accompanied by severe pain. (See Injuries of Nerves, Vol. III.)

I operated successfully upon a case of fracture of the upper third of the humerus, in which there was an excessive amount of new bone on the inner surface of the humerus which had produced pain and interference of function in the median and ulnar nerves. The symptoms disappeared permanently after the operation. The musculo-spiral nerve is sometimes pressed upon, or even included in the callus formation, in fractures of the shaft of the humerus. Symptoms of neuritis or partial or total suspension of function of the musculo-spiral nerve will be produced.

Weakness of the Callus.—As the result of local and general causes, a fracture which has united in an apparently normal way may gradually undergo a recurrence of deformity, usually angular, as the result of use, or fracture may take place through the callus as the result of slight degrees of violence. Under such circumstances, in the absence of depressed states of vitality from any cause, we may assume that, owing to imperfect reduction, or to interposition of soft parts, or to destruction of the periosteum, the bridge of bone between the fragments has been of insufficient strength. If a fracture occurs the signs and symptoms are those of recent fracture, but the swelling, pain, etc., accompanying a fresh fracture are less marked.

Stiffness of the Joints following Fracture.—Stiffness of the joints following fracture is observed in all cases. If merely due to disuse, it is gradually recovered from by active use of the limb. In the aged, or in rare cases where

from ignorance and fear of pain the individual will not use the limb, some limitation of motion may be permanent. In fractures accompanied by stretching or tearing of the ligaments of a joint the stiffness may be more marked, and in some instances a chronic arthritis, or even arthritis deformans, may follow, with permanent, partial, or complete loss of mobility in the joint. In fractures involving the articular ends of bones and passing into joints, such arthrites are fairly common. In these cases, also, a mechanical obstacle to perfect motion in the joint may exist by reason of the changed relations due to unreduced displacements or to the formation of callus and new bone.

Disturbances of Nutrition.—Following all fractures there is a certain amount of disturbance in the nutrition of the limb. The muscles are diminished in size. The limb is often swollen and blue; such signs are usually more marked, and last longer in fractures of the leg. In uncomplicated cases they are recovered from after a variable time, depending upon the local and general conditions.

Faulty and Fibrous Union.—When broken bones unite in such a manner that marked deformity or functional disability, or both, remain as the result of the permanent displacement of the broken bones, the condition is spoken of as *faulty* or *vicious union*, implying usually absence of or imperfect treatment. Such deformities are, of course, of a very varied character, are easy to recognize, and need no special description in this place. (See Regional Surgery.) When fractured bones unite by fibrous tissue merely, not by bone, an abnormal mobility remains at the point of fracture readily appreciated on manipulating the limb, and an actual space or separation can sometimes be detected between the fragments, notably in fractures of the olecranon and fractures of the patella. The condition is known as *fibrous union.*

Period Required for the Union of Fractures.—While no accurate estimate of the time required for the union of fractures can be made, the general average may be given as follows:

Metacarpal or metatarsal bones as well as ribs..	3 weeks.
Clavicle	4 "
Forearm	5 "
Humerus and fibula.....	6 "
Surgical neck of humerus and tibia.....	7 "
Tibia and fibula together.....	8 "
Femur	10 "
Neck of Femur	12 "

(É. Gurlt's statistics.)

Delayed Union and Failure of Union.—Comminuted fractures usually require a longer time for complete consolidation, and compound fractures, if infected, may take very long indeed. When the normal time for the union of a fracture has been considerably exceeded, the condition is spoken of as *delayed union*, and if union entirely fails after a considerable lapse of time,

the condition is known as *failure of union.* In certain situations, notably in the patella, the olecranon, and in some fractures of the neck of the femur, bony union seldom if ever takes place without operative interference, and in these cases we speak simply of fibrous union. The persistence of abnormal mobility is the characteristic sign of "delayed" or "failure of union." When the fracture is in the immediate vicinity of a joint, the mobility may be hard to make out by physical examination; pain and disturbance of function will be present, and a carefully taken X-ray picture will generally make the diagnosis clear. In recently united fractures the callus, or new bone, casts a shadow less dense than the shadows cast by the original fragments, but dense enough to be clearly seen as a bridge passing from one fragment to the other. When the shadow of the callus can be observed, even though faint, passing from one fragment to the other, the prognosis of ultimate union is favorable. In many cases of failure of union, notably of the bones of the forearm, with loss of substance, the shadow of the callus is entirely absent, or some callus may be evident around the end of one fragment and none around the other. Where no callus at all can be seen after several months the chances of bony union without operative intervention are very poor. In other cases atrophic changes can be seen to have taken place in the ends of the fragments; again the outlook is unfavorable.

Displacements.—The displacements of the bony fragments were classified by Malgaigne into six classes. One or several of these kinds of displacement

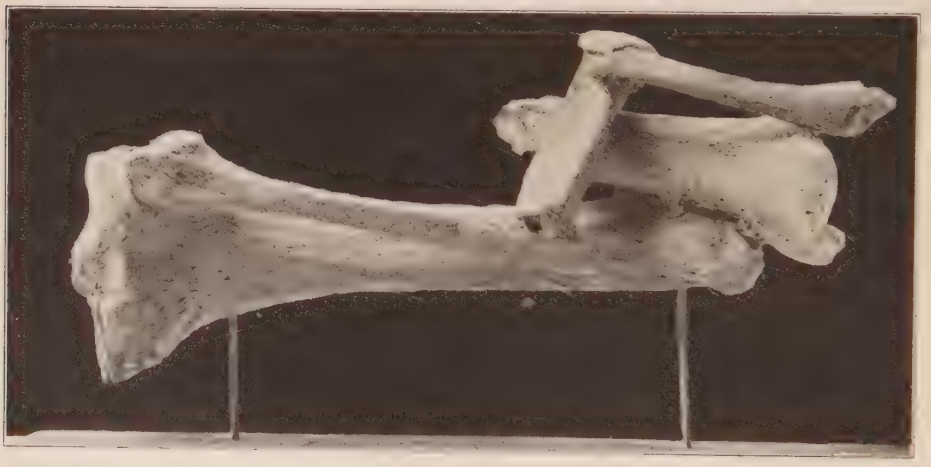


Fig. 113.—Fracture of the Tibia and Fibula, Union with Extreme Displacement. (New York Hospital Museum.)

may exist in the same fracture. They are, according to Stimson (L. A. Stimson, *loc. cit.*, page 34), as follows: The displacements may be in

1. The transverse axis of the bone—transverse or lateral displacement.
2. The long axis of the bone—angular displacement.

3. The circumference of the bone—rotary displacement.
4. The length of the bone—overriding.
5. Penetration of one fragment by the other—impaction and crushing.
6. Direct longitudinal separation.

Stimson adds a seventh class of irregular displacements, among them the interposition of a bone between the bony fragments of another. Rotation of a fragment upon its transverse axis—as in some fractures of the neck of the humerus. Crossing of the fragments like the letter X in some fractures of the clavicle. Interposition of the end of the shaft between the separated condyles —femur and humerus.

1. Transverse or Lateral Displacement.—The fragments are displaced completely or partially in a direction at right angles to the long axis of the bone. When this displacement is complete, it rarely exists except in combination with one of the other forms—angular, overriding, or rotary.

2. The Long Axis of the Bone—Angular Displacement.—Angular displacement occurs in complete and incomplete fracture, notably of the shafts of the long bones. It may be present to any degree, from the production of a

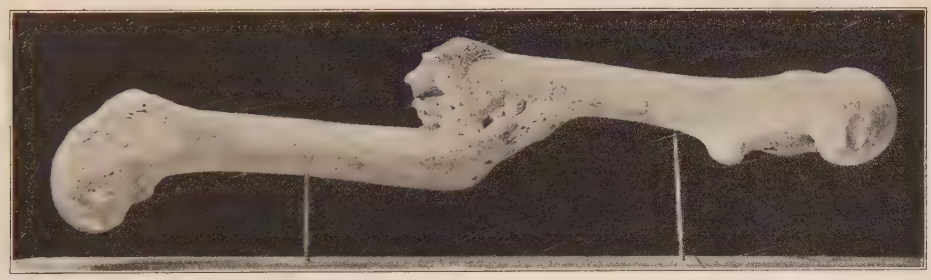


Fig. 114.—Fracture of the Femur, Union with Displacement. (New York Hospital Museum.)

slight angular deflection at some point in the bone, to a sharp bend at a right angle, or even more. In the long bones it is very easy to recognize if well marked, but at the ends of the long bones near the joints, and in short bones, notably when combined with crushing or impaction, its existence may be difficult to determine without the use of the X-rays.

3. The Circumference of the Bone—Rotary Displacement.—This form of displacement occurs when one of the bony fragments, usually the one farthest from the trunk, rotates about its long axis, while the other fragment retains its normal relations. It occurs most often as the result of gravity or of muscular action in fractures of the long bones, notably of the shaft of the femur, of both bones of the leg, and in fractures of the radius.

4. Overriding.—Overriding is a very common form of displacement in fractures of the shafts of the long bones, notably when the lines of fracture are oblique; it also occurs in transverse fractures combined with lateral and angular displacement. It produces shortening of the injured segment of the

limb, except where one of the bones remains intact, when shortening may be absent. Overriding is produced by a continuance of the violence after the fracture has occurred, by muscular action, and by the swelling of the limb following the fracture, as the result of the tension of the tissues, the circumference of the limb being increased at the expense of its length.

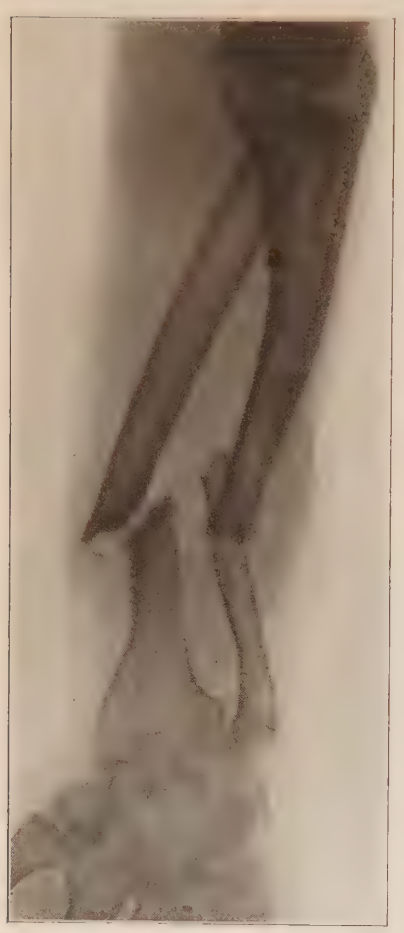


Fig. 115. — Fracture of the Radius and Ulna. Failure of union. Note the atrophy in the upper end of the lower fragment of the ulna. In this case repeated operations in the effort to bring about union between the bones failed. Case of Dr. F. T. Brown. (X-ray by the author.)

5. Penetration, Impaction, or Crushing.—This form of displacement occurs when one bony fragment is driven into or penetrates the other. It is very common at the upper end of the femur, fractures of the neck, and at the upper end of the humerus, lower end of the radius, and in general where the compact shaft of a long bone joins its spongy extremity. Crushing is common in the short spongy bones, such as the os calcis. The degree of impaction of one fragment into another varies greatly; it may be so slight as to be broken up during a gentle examination; it often happens that the impacted fragments are separated during efforts made to overcome the displacement; in other instances the impaction is so firm that the condition cannot be overcome by ordinary means, and is permanent.

6. Direct Longitudinal Separation. —This form of displacement is comparatively rare, and occurs in but few situations, notably in fractures of the patella, of the olecranon process of the ulna, and sometimes in fractures of the shaft of the humerus, below the insertion of the deltoid by the action of gravity when the elbow and forearm are not supported. In fractures of the patella and olecranon, the separation is maintained by muscular action, and by the tension of the joint capsule from effused blood.

DISLOCATIONS

A dislocation is a permanent separation of joint surfaces of bones normally in contact. The separation may be complete or partial. *Complete dis-*

location when the joint surfaces are entirely separated or touch only at their edges, or *partial* (subluxation) when some part of the joint surfaces still remain in contact. When by rupture or stretching of joint ligaments the joint surfaces are separated, but return immediately to their normal relations, the condition is called a *sprain* or *distortion*. Dislocations are designated by the name of the joint whose bones are displaced, or by the name of the distal bone or bones forming the articulation. Thus we may speak of a dislocation of the shoulder or hip as a dislocation of the humerus or femur, respectively. When both ends of the same bone are dislocated, the condition is sometimes called a total *dislocation*. By *diastasis* is meant a direct tearing apart of the bones, as in separation of the pubic bones at the pubic symphysis or separation of bones along a line of suture, as in separation of the bones of the skull. A *compound dislocation* is associated with a wound communicating with the external air. A *complicated dislocation* is associated with a fracture, or with injuries of the soft parts, blood-vessels, nerves. Dislocations may be *traumatic*, *congenital*, or *pathological* (spontaneous, inflammatory dislocation). The first are the result of sudden violence. The second occur during intrauterine life from imperfect development of the joint structures, and the third occur as the result of disease of the bones or the joints themselves, sometimes as the result of diseases of the spinal cord. These may be sudden or gradual in their production.

Traumatic Dislocations.—Dislocations are much less frequent injuries than fractures, the proportion being about one to ten. They may occur at any period of life. Dislocations are more common in the upper extremity than the lower. The shoulder is most often dislocated, the joints of the fingers next, the elbow next.[1] Stimson's statistics of the dislocations occurring in the Hudson Street Hospital in New York, 1894–99, showed that out of 705 dislocations, 27 were of the lower extremity, and of these, 9 were of the hip, 8 of the knee; 633 were of the upper extremity, and of these, 287 of the shoulder, 67 of the elbow, 175 of the metacarpo-phalangeal and phalangeal joints; 45 were of the head and trunk, and of these, 41 of the lower jaw and 3 of the vertebræ. Traumatic dislocations may occur as the result of direct or indirect external violence or from violent muscular action.

Dislocations by Direct Violence.—Dislocations due to direct violence are infrequent; they occur when the force is applied directly to the articular end of one of the bones forming the joint, whereby it is simply forced directly away from the other bone. It does not usually occur from an exaggeration of some normal movement of the joint, but often in a direction in which the joint has no normal movement at all, frequently in a direction parallel with the plane of the joint surfaces. Owing to the considerable force necessary to produce a dislocation by direct violence, fractures are a common complication.

[1] L. A. Stimson. "Fractures and Dislocations," 3d edition, p. 407. Lea Bros.

Dislocations by Indirect Violence.—The force is applied at some distance from the joint, either to the shaft of the bone, to its other end, or through the medium of other bones. The violence may act in a variety of ways. It may be applied directly in the long axis of the bone, so that its articular surface is simply caused to slide away from that of the other bone forming the joint, the limb being at the time in a position favorable for such an occurrence. More commonly the mechanism is one of leverage; the force acts upon the shaft of the bone forming the long arm of the lever to produce an exaggeration of some normal motion until finally checked by a bony prominence or the tension of a ligament; the force continuing to act, the bony prominence or the ligament becomes a fulcrum, and later a center of motion about which the articular extremity of the bone—the short arm of the lever—continues to move until the joint surfaces are pried apart. In other cases the violence acts to produce motion in the joint in a direction in which no motion normally occurs, or only to a limited extent, or only in certain positions of the joint. Such motions are not infrequently motions of abduction, adduction, or rotation. Examples—the knee, ankle, elbow. In order to produce dislocations in this manner considerable degrees of violence are required, and associated injuries of the bones and soft parts are common.

Dislocations by Muscular Action.—Dislocations due to muscular violence are comparatively rare; they most frequently occur as the result of the violent convulsive movements accompanying hysteric, uremic, or other convulsions; their mechanism in this case may be either that of indirect or direct violence—that is to say, the violent motion may carry the limb beyond its normal range, so that a leverage occurs, the joint surfaces are pried apart, and dislocation results; or, on the other hand, a certain set of muscles may act violently upon the head of the bone, cause rupture of the ligaments of the joint and dislocation.

Recurrent or Habitual Dislocations.—It occasionally happens that traumatic dislocations of a joint, usually the shoulder, but sometimes other joints, recur, from time to time, from slight degrees of mechanical violence. Such conditions are due to imperfect repair of ruptured ligaments or muscles, or from a fracture of the rim of a glenoid cavity which has resulted in deformity, or which has been imperfectly repaired. In such cases, also, the capsule of the joint may be relaxed, imperfect, or extensively stretched. A similar condition may be produced by the paralysis or atrophy of muscles surrounding a joint.

Complications Attending Dislocations.—The complications attending dislocations are many and serious.

Fracture of the Dislocated Bone.—Among these complications is fracture of the dislocated bone, either of its entire shaft close to the dislocated end, or of the tearing away of portions of the head of the bone by muscles, tendons, or ligaments.

Injuries to the Blood-vessels.—The injury of the main blood-vessel of a limb is uncommon as the result of a simple dislocation. If the main

artery of the limb is torn or severely stretched, a traumatic aneurism may form immediately or later, or gangrene of the limb may result. The artery usually involved has been the axillary in anterior and internal dislocations of the shoulder. The danger of gangrene is, of course, greater if the main vein of the limb is also injured.

Injuries of the Nerves.—Injuries of the nerves may be produced directly by the same violence which caused the dislocation, or they may occur by the pressure of the displaced head of the bone. The symptoms will vary according as the nerve trunk is actually torn across, or is merely contused, stretched, or compressed. In the first instance, the symptoms will be immediate and complete loss of sensation and motion in the area supplied by the nerve. If the injury to the nerve has been incomplete, the symptoms will consist of partial, sensory, or motor paralysis, followed later in certain instances by neuritis, which may extend to other nerves.

It may be well to remark here that in every case of dislocation it is the duty of the surgeon, as well to the patient as to himself, to examine carefully for the signs of injury to important blood-vessels, as indicated by weakness or absence of pulsation in the peripheral arteries, sudden or excessive swelling in the neighborhood of the dislocated joint, or swelling of the limb; paralysis of motion or sensation in the extremity. This examination should precede the efforts at reduction, and the patient's attention should be called to the existence of any of these abnormalities, if found, in order that the condition may not subsequently be regarded by the patient as the result of the treatment. Dislocations may, furthermore, when they occur in bones close to the trunk, cause pressure upon important structures, and dangerous, or even fatal symptoms. Dislocation of the inner end of the clavicle may cause pressure upon the trachea and esophagus.

Compound Dislocations.—Compound dislocations are usually caused by extreme degrees of violence. The laceration of the muscles, of other soft parts, and of the skin are usually produced by the violence which caused the dislocation continuing to act, thus forcing the bones from within outward through the tissues. They are rare, and occur oftener in the knee, elbow, ankle, and phalanges than elsewhere. The coexistence of lacerated wounds of the soft parts, and of a wound opening into the interior of a joint thereby exposed to infection, together with the not infrequently associated injury of important blood-vessels in these cases, renders the compound dislocation of a large joint a very grave injury indeed.

Diagnosis of Dislocations.—The signs and symptoms whereby we recognize the presence of a dislocation are partly objective and partly subjective, such as can be observed by the surgeon, and those of which the patient himself is cognizant. The former consist of *deformity*, of *limitation of motion*, of *crepitus*. The subjective symptoms consist of *pain*, of *loss of function*, and of the *history of the accident*. While the diagnosis of many dislocations can be made at a glance, sometimes from the mere attitude or gait of the patient, yet certain

dislocations, notably when accompanied by much swelling from extravasated blood, and those complicated by fracture, offer very great difficulties. As in fractures, it is desirable that the patient should be so far unclothed that both sides of the body may be examined and compared. It is often desirable that the patient should be prepared to take an anesthetic. The examination of dislocations and their reduction is often painful.

Differential Diagnosis.—The differential diagnosis between dislocations and fractures in the neighborhood of joints can often be made more readily when the patient is under an anesthetic and the muscles are entirely relaxed. The abnormal position assumed and maintained by the head of a dislocated bone does not depend upon the spasmodic or tonic contractions of muscles, but upon the tension of ligaments or of untorn portions of the joint capsule, and upon the mechanical relations of the displaced bones. A deformity due to muscular action, or maintained thereby, disappears under a general anesthetic, not so the deformity of a dislocation. As already noted, the examination should include a determination of whether injuries of blood-vessels or nerves are present. In cases where doubts exist the X-rays should be used.

History.—In the diagnosis of dislocations it is very important to learn if possible the position of the limb at the time of the accident, the manner in which the force was exerted, the position which the limb assumed immediately after the accident, and whether this position has been maintained or has changed to some so-called secondary position. It is very desirable to know how, in what direction, and at what point the bone left its socket, and tore through the capsule of the joint, because the manipulations for the purpose of reduction will depend largely upon a knowledge of these data.

Soon after the occurrence of a dislocation swelling takes place in the neighborhood of the joint from effused blood. *Ecchymosis* will follow, but does not usually reach the surface for hours or days. If the dislocation has been caused by direct violence there will be the evidences of contusion.

Inspection.—By inspection, also, the position of the limb is to be compared with that of the normal side; this is, in general, a most valuable aid in the diagnosis; in many instances it is so entirely typical as to render the presence of a dislocation quite certain. A departure from this rule occurs in those so-called atypical dislocations in which the ligaments which hold the dislocated bone in its abnormal position have been extensively torn. One of the characters to be noted is that the long axis of the bone is not directed toward its proper position in the joint, but to one side of the same. Frequently it is possible to see that the prominence normally created by the head of the bone is lost, and that a depression exists in its place. The head of the bone in its new situation may, on the other hand, cause a visible swelling.

The apparent or real shortening or lengthening to be noted in some dislocations is not as valuable a sign as it is in fractures for several reasons: First, it is not usually possible in dislocations to place the two limbs in the same relative position in respect to the trunk, and, as has been pointed out in the case

of fractures, this is essential to correct comparative measurements. Second, the proximal bone is frequently held in a more or less fixed position by the voluntary contraction of the muscles, and such a position, tilting of the pelvis or of the scapula, for example, may make the limb appear lengthened or shortened, as the case may be.

Palpation.—The most valuable objective signs are to be determined by *palpation*—namely, the actual recognition of the head of the bone and its relation to the joint cavity. No amount of pains should be spared to accomplish this, for without it the diagnosis of dislocation is often incomplete. The head of the bone may often be grasped between the examining fingers and its contour recognized. In deeply placed bones this cannot always be accomplished. An effort should also be made to feel with the fingers that the cavity where the head of the bone belongs is empty. The position of the head of the bone may, however, often be inferred from the attitude of the limb, abduction, adduction, rotation, or from the position of some bony prominence, the relations of which to the head of the bone are known, the external condyle of the humerus, for example, in dislocations of the head of the radius. If the head of the bone is once found, its identity may be established by finding that it participates in motions communicated to the shaft. When great swelling exists the use of a general anesthetic greatly facilitates the examination, and enables the surgeon to push away the extravasated blood and to diminish the edema by pressure, so that the extremity of the bone can be more readily felt.

Stereoscopic Radiographs.—As in fractures, *stereoscopic radiographs* afford great assistance in the diagnosis of doubtful cases of dislocation, and especially of dislocation complicated by fracture. Owing to the presence of large amounts of extravasated blood and to the occasional difficulty of arranging the dislocated joint in a proper relation to the tube, and to the photographic plate, excellent pictures are not always easy to obtain, but they can usually be made sufficiently good to establish the diagnosis clearly.

Limitation of Motion.—The position of the rent in the capsule and the relation of the dislocated head to the untorn and tense ligaments is found to vary in a typical and definite manner in the different varieties of dislocation. Any motion tending to increase the tension of the ligaments is resisted; other motions, notably those which relax the stretched ligaments, can still be made. This resistance to motion in certain directions and mobility in others is characteristic of the different forms of dislocation. Immobility may be increased by muscular spasm due to pain or diminished by extensive laceration of the ligaments. The position assumed by the limb is also characteristic; when moved, the limb tends to return to it spontaneously, and this tendency is not changed by anesthesia. (See Special Dislocations.)

Crepitus.—During the examination of a dislocated limb a grating may be perceived as the head of the bone is moved in its new position. This may be due to the rubbing of one bone against the other or against the border of a stretched tendon or edge of fascia. At the moment when reduction is accom-

plished, in a joint like the shoulder, a sharp grating or click is often noticed. It should not be forgotten that the crepitation may be due to an associated fracture.

Subjective Symptoms.—Pain. A sharp pain in the vicinity of a joint is felt at the moment of dislocation; the pain may continue unabated if nerves are stretched, pressed upon, or torn, or be associated with numbness; often it soon subsides, but returns or is increased by efforts to move the limb or by jolting movements communicated to the body.

Loss of Function.—Commonly the dislocated limb is quite powerless. The symptom is of no great diagnostic value, since it usually accompanies fractures and may follow contusions. Sometimes the patient is still able to use the limb, and if reduction is not affected, motion, restricted, but perfectly efficient in certain directions, may be gradually restored.

Differential Diagnosis of Traumatic Dislocations.—In sprains, the history of the injury, the pain, and the swelling are similar. The joint is often immobile on account of pain. Under anesthesia the immobility disappears, and the joint can then be moved freely. Fractures in the neighborhood of joints, and notably impacted fractures, are at times not easy to differentiate from dislocations, if, when first seen, much swelling exists. Abnormal mobility and crepitation, of course, indicate fracture. The deformity of fracture if not impacted may often be readily reduced, but returns at once; the deformity of dislocation may be difficult to reduce, but once effected, the deformity does not return. In cases of doubt, examination under general anesthesia is always advisable. An X-ray picture will usually establish a correct diagnosis.

Congenital Dislocations.—Congenital dislocations are due to arrest of development or deformity of the articular extremities or surfaces of a joint. They are far more common in the hip than in any other joint, but occasionally occur in the elbow, the shoulder, and other joints. Frequently they are not noticed in the hip-joint until the child begins to walk. The signs of traumatism are of course absent, and instead of fixation or limitation of motion in the joint an abnormal degree of mobility exists, due to the imperfect development of the end of the bone and to the relaxed ligaments and joint capsule. The diagnosis is made by the discovery of the head of the bone in an abnormal position, the shortening of the limb, and the deformed appearance of the joint itself. In the hip the shortening leads to a limp, and if but one joint is affected to scoliosis, which is quite marked, but can be overcome temporarily by having the child place the affected foot upon a book or other object of suitable height.

In single and double dislocations there is marked lordosis in the erect posture, which disappears when the child is placed flat upon its back. In double dislocation also the child has a peculiar waddling gait, which is fairly characteristic. An absolute diagnosis is made by feeling the trochanter, and sometimes the head of the bone upon the dorsum of the ilium, the ordinary form of dislocation. The articular extremity is displaced upward, and measured shortening is well marked. The bodies of these patients being small, very

perfect X-ray pictures are easily taken, and demonstrate the condition beyond the shadow of a doubt.

Pathological or Spontaneous Dislocations.—These are always acquired, are the result of disease, sometimes of the joint itself, sometimes secondary to other diseases. They were divided by Volkmann into three groups, as: First, dislocations by distention; second, by destruction; third, by deformity.

1. Dislocations by Distention.—It was believed by Volkmann, and has been held by others, that these dislocations occurred as the result of the distention of the capsule of the joint by fluid exudates. The result of synovites of an acute character, such as acute articular rheumatism, the metastatic synovites complicating the acute exanthemata, typhoid fever, pyemia, etc., and gravity and muscular action, were regarded as secondary factors in the production of the dislocation. It was pointed out by Stimson,[1] however, that the marked distention of the joint is assumed rather than demonstrated, and that these dislocations occur in cases where pain and muscular spasm are marked, and when the limb has long been held in such a position that gravity and muscular action favor the occurrence of dislocation, and Stimson believes that these two latter factors are the true cause of the dislocation, rather than the relaxation of the joint capsule produced by overdistention. He considers that the effusion into the joint favors the occurrence of dislocation merely by removing the influence of atmospheric pressure in holding the joint surfaces together.

The dislocation occurs most often in the hip-joint when patients with a painful affection of the joint have lain for a considerable time with the limb in the position of flexion, adduction, and internal rotation. The dislocation occurs suddenly upon the dorsum of the ilium, and is usually followed by relief of pain. The diagnosis is made by the ordinary methods of examination, and reduction is effected by manipulation, and is permanent.

2. Dislocations by Destruction.—In these the dislocation is produced by destruction of the articular ends of the bones, such as occur in the course of joint tuberculosis, in tabetic joints, or as the result of acute suppurative joint lesions with destruction of the ligaments. Paralysis of the muscles surrounding a joint may result in dislocation in one of two ways. If all the muscles are paralyzed, an important part of the support of the articulation is lost, and the bones, as sometimes happens in the shoulder-joint, may simply fall away from one another by gravity; such a dislocation is accompanied by a serous effusion into the joint. When only certain groups of muscles near a joint are paralyzed while other groups continue to act unopposed, the latter may produce a dislocation by muscular contraction; such dislocations have been noticed (hip) in the course of spinal caries, producing pressure upon the spinal cord and paralysis of the adductors of the thigh or of the external rotators attached to the trochanters. If the adductors are paralyzed while the muscles upon the outer side and back of the thigh continue to act, the dislocation will

[1] Stimson, *loc. cit.*, p. 477.

be upon the pubis. If the trochanteric muscles are paralyzed while the adductors act unopposed, the dislocation will be upon the dorsum of the ilium.

A very common form of partial dislocation the result of muscular contraction is the dislocation backward of the tibia in untreated tuberculosis of the knee-joint produced by the action of the hamstring muscles. When one of two paired bones grows faster than the other, or the development of one of them is arrested, and in a few cases of compound fracture of one of two paired bones, with loss of substance and failure of union of one of the bones, a gradual, complete, or partial dislocation by muscular action may occur.

3. Dislocations by Deformity.—Under this head Volkmann and other authors have included the dislocations which occur in arthritis deformans and in tabes—"Charcot's joint." The dislocation is produced partly by atrophy and absorption of bone and partly by the growth of new bone forcing the articular surfaces into an abnormal position. The dislocations may be sudden or gradual in their occurrence, and complete or partial.

CHAPTER IX

SYPHILIS AND LEPROSY

SYPHILIS

Syphilis is a chronic, contagious, infectious disease, produced by inoculation with the syphilitic virus or contagium. It is hereditary in the sense that it may be transmitted to the offspring of the syphilitic individual. The course of the disease and the character of its lesions present so many resemblances and analogies to chronic infectious diseases known to be of bacterial origin that it has long been the belief of pathologists that syphilis must have a similar causation.

Syphilis has long been studied clinically and experimentally in the search for its essential cause, and a large number of bacterial forms have from time to time been found in syphilitic lesions. None of these have been shown to bear a causative relation to the disease. In 1905, however, Schaudinn and Hoffmann discovered in the secretions of syphilitic sores an organism hitherto undescribed, which they believed might be the cause of syphilis, and their observations have since been confirmed by a very large number of observers.

The organism is quite regularly found in the lesions of early untreated syphilis. It has been found in the blood of syphilitic patients, and in some of the later lesions of the disease. Though the organism has not been cultivated, and but little is known of its life history, yet a constantly accumulating mass of evidence seems to point to the conclusion that the Spirocheta pallida (Spironema, treponema pallida) is the exciting cause of syphilis.

The Spirocheta pallida.—The Spirocheta pallida may be examined alive in the secretions of an open syphilitic lesion, best during the early stages of the disease. The scrapings from a syphilitic sore may be mounted under a coverglass protected from evaporation by sealing with wax or paraffin. The best results are obtained by scraping the lesions quite deeply. The fewer leucocytes in the exudate the more spirochetæ it is likely to contain (Ewing).

It is a spiral organism (see Fig. 116), which varies in length from 4–14 μ. Its diameter varies from $\frac{1}{4}$ μ to immeasurable tenuity. It is cylindrical, and shows usually from six to twelve spirals, though as many as twenty have been observed. The length and depth of the spirals varies from 1–1.5 μ. The organism is motile, and shows motion of three kinds: a rotation upon its long axis, a bending upon its axis, and a to-and-fro movement. In fresh prepara-

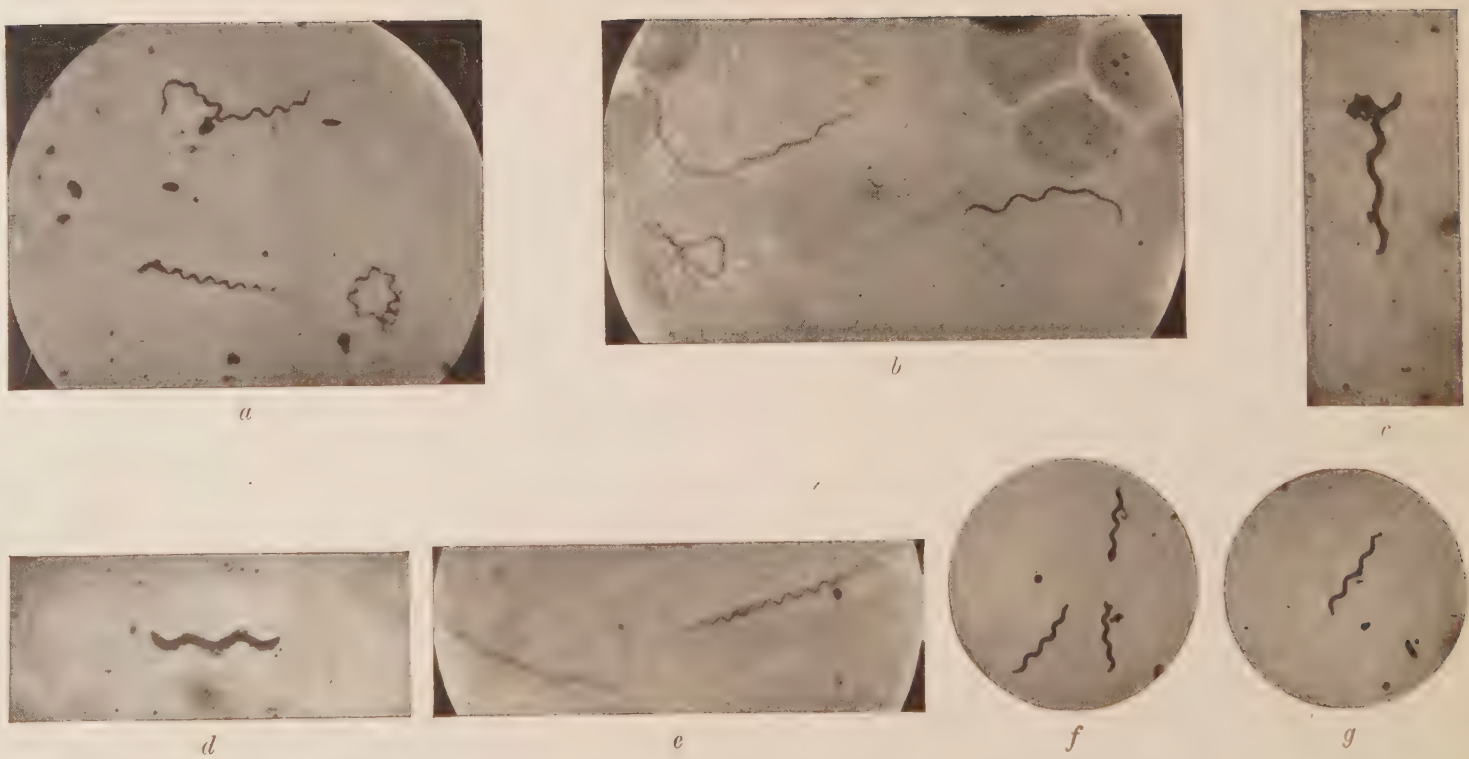


FIG. 116.

(*a*) Spirochæta pallida. Remarkably intense stain; shows flagella, one of which is bifurcated. The distortion of the spirochæta is unusually great. (Schaudinn.)

(*b*) Contrast between Spirochæta pallida and Spirochæta refringens; the former in the center of the field (two specimens) very faintly stained, but with numerous sharp curves, the latter more deeply stained and only slightly undulating. (Schaudinn.)

(*c* and *d*) Spirochæta dentium or buccalis, a short, thick, long-curved, deeply staining organism found in the mouth. (Hoffmann and Prowazek.)

(*e*) Two typical Spirochætæ pallidæ. (Schaudinn.)

(*f* and *g*) Spirochæta balanitictis, similar to Spirochæte buccalis. These specimens show flagella, in one instance apparently joining two spirochætæ. (Schaudinn.)

tions the motions are quite active, though the organism does not notably change its position. Though the spirochetæ may be observed in the living state, they are best seen and studied after staining. Whether in secretions or in the tissues, they are found almost without exception outside the cells. The following description of the staining methods, as well as the figures showing the organisms in secretions and tissues, are quoted from "Syphilis," by Edward L. Keyes, Jr.:

Methods of Staining.—The Spirocheta pallida approximates the protozoa in its resistance to the usual bacterial stains. The classic method of preparing and staining is Schaudinn and Hoffmann's modification of Giemsa, as follows:

1. Obtain the specimen by scratching the surface of the lesion (chancre, mucous patch), after having washed it thoroughly clean of all contamination—the admixture of a trace of blood does no harm. Spread the secretion thus obtained as thin as possible; *dry without heating*; harden for fifteen minutes in absolute alcohol.

2. Employing the Giemsa stain (made by Grübler, of Leipzig), dilute this by adding about 1 drop to 1 c.c. of water (to which 1 to 10 drops of 1:1,000 calcium carbonate has been previously added—this is advantageous but not essential).

3. Immediately spread the diluted stain on the specimen and let it stand one hour.

4. Wash freely in water, dry without heating, and mount.

This is the standard stain. A quicker method is that of Simonelli and Bandi[1] or of Goldhorn,[2] sold in this country under the name of Goldhorn's stain. A few drops of this will stain a specimen (dried without heating) in two or three seconds. The smear is then rinsed in water and dried (cold).

In France a favorite stain is the Marino blue; innumerable other stains have been tried, but the Giemsa and the Goldhorn fill all requirements.* With Giemsa the spirochetæ appear of a faint red color. The Goldhorn stains them purplish, which may be changed to brownish-black by treating the specimen with gram or lugol.

Tissue Stain.—The best is Levaditi's modification of the Ramon y Cajal silver stain.[3]

1. Sections are cut 1 mm. thick and hardened in ten per cent formalin for twenty-four hours.

2. Wash and harden in ninety-six per cent alcohol twenty-four hours.

3. Wash a few minutes in water until they sink.

4. Impregnate with silver by soaking for three (to five) days in a 1.5 per cent (to three per cent) solution of silver nitrate at a temperature of 38° C.

5. Wash rapidly in water and place for twenty-four (to forty-eight) hours at the room temperature in

Acid pyrogallic	2 gm.
Formalin	5 c.c.
Aq. destill.	100 c.c.

[1] *Centralbl. f. Bact., Parasit. v. Infect.*, 1905, vol. xl, p. 159.

[2] *Jour. of Exper. Med.*, 1906, vol. viii, p. 451.

[3] The so-called old Levaditi, in contradistinction to the new or pyridin Levaditi, which is quicker but not so accurate.

6. Wash, dehydrate in absolute alcohol, and mount in paraffin.

7. Cut sections no thicker than 5 μ.

8. Stain either with (*a*) Giemsa, for a few minutes; wash in water, differentiate in alcohol containing a few drops of oil of cloves, clarify in xylol, and mount in balsam; or (*b*) concentrated toluidin-blue solution, differentiate in alcohol containing a few drops of Unna's ether-glycerin mixture—xylol, balsam.

Diagnosis of Spirocheta pallida.—The time and skill required to perform the Levaditi stain successfully suffice to keep tissue staining apart, to be employed only by the most competent specialists. Current examinations for Spirocheta pallida may be attempted only on smears stained with Goldhorn or Giemsa.

Examination of such a smear promptly reveals how appropriate is the name, Spirocheta pallida; for so pale and thin are these microörganisms, that at first one finds great difficulty in perceiving them. It has been generally noted that the observer at first makes very few positive finds. But, having at last identified the spirocheta and got it photographed, as it were, on his retina, he can return to specimens previously found negative and discover the organism in them—perhaps in great numbers.

Hence the discovery of Spirocheta pallida requires not only familiarity with ordinary laboratory and microscopic technic, but also a relatively long and tedious special training. Unhappily, it is to be foreseen that, as spirocheta diagnosis assumes greater and greater prominence in the diagnosis of syphilis, the tribe of near pathologists will feel fully competent to pass upon this—the most delicate point in the diagnosis of the most important infectious disease that afflicts mankind; to the cocksure diagnosis of the hasty practitioner will be added the scientific diagnosis of incompetence. For spiral organisms abound both upon the skin and upon the mucous membranes. In the mouth are found Spirocheta denticula, Spirocheta buccalis, Spirocheta Vincenti; in the bowel, Spirocheta dysenteriæ; on the skin, Spirocheta refringens and various saprophytic varieties.

The accompanying photographs (Fig. 116) show, however, the characteristic features distinguishing Spirocheta pallida from every other variety of spirocheta. These are:

1. Extreme tenuity and faint staining.

2. Multiple small, abrupt spirals.

All of the other familiar spirochetæ are much thicker (most of them are longer), stain readily with the common dyes, and exhibit long, gentle undulations in brilliant contrast to the sharp, short, almost angular spirals of Spirocheta pallida.

This is not to say that every Spirocheta pallida seen can be identified as such, or that every specimen containing Spirocheta pallida can be diagnosed even by the most skilled observer. Indeed, quite the converse is true. Even Neisser confesses to a doubt about certain of his cases. But a characteristic Spirocheta pallida is as typical to a skilled eye as is a characteristic gonococcus, for example, and affords quite the same diagnostic certainty.

But before a negative report can be given, repeated, prolonged, systematic, and skilled examinations must be made.

Where may Spirocheta pallida be Found?—The earlier observers were able to discover Spirocheta pallida only in the earliest (and most infectious) lesions of the disease. The following condensed list shows the results obtained by those reporting the greatest number of cases:

Oppenheim and Sachs examined 118 cases, with 39 positive results.

Mulzer, 22 cases, 2 positive; 56 controls, all negative.

Nicolas, Favre, and André, 42 cases, 13 positive.

Kraus and Prautschoff, 37 chancres, 32 positive; 25 secondaries, 18 positive.

Siebert, 18 chancres, 13 positive; 46 secondaries, 39 positive; 46 control examinations negative; 6 lymph node serum negative; 7 gummata negative; cerebrospinal fluid, blood and semen negative.

Sobernheim and Tomasczewski, 50 cases, all positive; 28 controls, all negative.

Scholtz, 37 cases, all positive.

Schaudinn (second report), 70 cases, all positive.

Roscher, 32 chancres, 31 positive; 58 moist papules, 55 positive; 40 dry papules and pustules, 34 positive; 29 mouth lesions, 28 positive; 38 lymph node serum, 30 positive; 24 controls negative.

Sufficiently expert and conscientious investigation, therefore, reveals Spirocheta pallida in fully three fourths of the smears taken from chancres, moist papules, and mouth lesions.

It was to be hoped that aspiration of the lymph nodes adjacent to the chancre might prove a simple means of obtaining uncontaminated smears of Spirocheta pallida; but, unfortunately, the microörganism is rare in the center of nodes, being chiefly confined to the region of the periphery, so that there is a distinctly less probability of finding them there than in the chancre itself.

Though the later secondary lesions contain fewer spirochetæ, these have been found as late as nine years after chancre by Sobernheim and Tomasczewski.

They have been found in the pus from a nonsyphilitic abscess occurring during the acute stage of the disease (Flügel), in the serum of blisters raised by cantharides (Levaditi and Petresco), in albuminous urine (Dreyer and Toepel), in the blood—after many failures, and only during the first few months and before the beginning of mercurial treatment (Nöggerath and Stähelin, Schaudinn, Richards and Hunt *et al.*).

Most interesting of all has been the search for spirochetæ in tertiary lesions, which, for a long time, was fruitless, but was finally crowned with success. Tomasczewski, who has found them in five out of ten gummata examined, states that eight to ten hours must sometimes be spent in examining smears before finding a typical spirocheta.

The moist lesions of early hereditary syphilis swarm with spirochetæ, and they have been found (either in smears or in sections) in practically all the organs of stillborn syphilitic infants; viz., liver, lung, spleen, kidney, suprarenal muscle, heart, stomach, intestine, mesenteric glands, gall-bladder and ducts, ovary, uterus, prostate, testis, urinary bladder, thymus, tonsil, bone, joint, etc. They are usually most numerous in the liver, lungs, and skin. They have been found in both fetal and maternal placenta, and once in the inguinal glands of the apparently healthy mother of a syphilitic child (Buschke and Fischer)! Curiously enough, masses of spirochetæ are sometimes found in and about the capillaries where no tissue change has taken place.

They have not been found in the cerebrospinal fluid, though they doubtless will be, for positive inoculations have been obtained upon monkeys with this fluid (Hoffmann).

The examination of normal secretions—except the semen—is always negative,

except in severe congenital syphilis. Whether the exception in the case of semen is due to syphilitic lesions in the seminal canals it is impossible as yet to say.

Distribution and Fate.—Though spirochetæ have been kept alive for a few days on artificial media, none of the attempts at artificial cultivation have thus far been successful.[1] Hence we are not in a position to affirm with absolute certainty that the spirocheta is self-sufficient, self-multiplying, like the known bacteria, and not a mere developmental form of some unknown organism (possibly the cytorrhictes). Moreover, the multiplication, distribution, and fate of the spirocheta in the body of a syphilitic patient have not been worked out in detail. But the following facts we know:

Spirochetæ are found most frequently in the earliest and most infectious lesions of syphilis. Whether in the chancre and early secondary lesions of acquired syphilis or in the organs in inherited syphilis, they abound in the walls of the blood-vessels and in the perivascular tissues. They are relatively rare in the lymph vessels, surprisingly few in the nodes, and when found in the nodes are usually in or about the blood capillaries at their circumference (Hoffmann and Beer). They have been found in great numbers among the epithelia of the chancre or the moist papule. A few observers believe they have seen evidence that the spirochetæ are destroyed by phagocytosis. In tertiary lesions (gummata) they have been found only in the active, advancing edge of the lesion, never in its necrotic center or in its secretion.

It seems probable, therefore, that the spirochetæ are distributed by the lymph rather than by the blood current, directly excite the perivascular inflammation characteristic of all syphilitic lesions, and are destroyed by phagocytosis.

Although a few observers have denied that the administration of mercury has any effect upon the spirocheta, it is the consensus of opinion that, as soon as mercury is administered, the spirochetæ rapidly disappear and soon are undiscoverable, and this disappearance seems to be especially rapid under inunction and hypodermic medication.

Symptoms of Syphilis.—Following inoculation with the syphilitic virus there occurs, after a period of incubation which is rarely less than two weeks and may be six weeks or more, a cellular infiltration at the point where the inoculation took place with the production of a small nodule usually characterized by hardness or induration. This is the so-called *initial lesion* of syphilis, the *hard chancre*, *Hunterian chancre*. After a brief interval the lymphatic glands of the region become enlarged and hard. Subsequently the lymphatic glands of other regions undergo similar enlargements, there follows some disturbance of the general health, accompanied in many cases by slight fever, and the outbreak upon the general integument and mucous membranes of a series of eruptions—roseola, erythema, papules, pustules. These eruptions are at first general and superficial; at a later period they are commonly grouped, and of a less superficial character. The disease may end here and the patient have no further symptoms during his lifetime, or at once, or after any possible

[1] Quite recently Spirocheta refringens has been cultivated by Levaditi; Spirocheta obermeieri by Novy; perhaps Spirocheta pallida will be the next.

interval, subacute and chronic inflammations may occur in any of the tissues of the body. Very often these later lesions of the disease are in the form of small or large nodular infiltrations, which tend to undergo a peculiar form of degeneration; they are known as *gummata*, and are especially prone to involve the connective tissues.

A further series of lesions occur as the result of syphilis; they are notably, sclerotic changes in the central nervous system and changes in the walls of the arteries, notably of the smaller arteries of the brain.

During the period when active symptoms are present, always for several years, and in most instances during his entire lifetime, the individual enjoys immunity from infection with the virus of syphilis. There are two further kinds of immunity from syphilis which may be important from a diagnostic point of view: First, the wife of a syphilitic man may give birth to a syphilitic child, show no symptoms of the disease herself, and yet be immune to syphilis. Second, syphilitic parents may give birth to healthy children, who never show any symptoms of the disease, but are immune. The immunity of an individual inoculated with syphilis begins at or before the time of the appearance of the initial lesion.

It is customary, in describing the disease, to divide it into a number of different stages or periods, but it is to be remembered that these stages are for the most part artificial—that is to say, the process of the invasion of the organism is continuous from the start and the successive groups of lesions occur simply as the result of the successive involvement of various kinds of structures—and that in many cases the several types of lesion, by the characters of which and the date of their appearance the disease is divided into a number of stages, may follow one another after longer or shorter intervals, or in rapid succession, or they may be coexistent. The general symptoms of intoxication may be immediately followed by lesions ordinarily occurring late in the disease, or rarely the initial lesion, or what appears to be an initial lesion, may be followed by no further symptoms whatever.

In a certain large proportion of cases, however, the course of the disease is marked by more or less definite stages or periods: First, a period of incubation, from the time of the inoculation until the appearance of the initial lesion, from ten days to six weeks; on the average about twenty-one days. Second, the primary period of the disease, consisting of the initial lesion and the associated adenitis of the neighboring lymph glands. The duration of the existence of the initial lesion is very variable, and will be discussed later on. A second period of so-called incubation occurs, during which the virus is slowly being disseminated throughout the entire organism; it ends with the appearance of the secondary symptoms. Its duration is variable, but is in general from eight to nine weeks from the time of inoculation, or six weeks from the appearance of the initial lesion. It may be prolonged several months. In one experimental inoculation it is said to have been prolonged to one hundred and fifty-nine days.

The Period of Secondary Symptoms, Secondary Syphilis.—The symptoms during this period consist chiefly of lesions of the skin and mucous membrane, though many other structures may be involved. They include macules, papules, pustules, and affections of the appendages of the skin, the hair and nails, the eye, and the equivalent of the various skin lesions as they occur upon the mucous membranes. This period is of variable duration—from one to three years. An intermediate period following this is described, during which either no symptoms at all are present or the symptoms are of an irregular character, localized rather than general. The patient may or may not be contagious, and may or may not infect his offspring. The duration of this period is variable; it may last from one to several years, and end in recovery without further symptoms, or be followed after an indefinite interval by the so-called tertiary lesions of the disease. These consist of more deeply seated, sometimes destructive, lesions of the skin and mucous membranes and subcutaneous connective tissues, of inflammations of the bones, of the internal organs, of inflammations of the arteries, the formation of gummata. The duration of the period is indefinite.

Infection with Syphilis.—Infection may occur from the inoculation from the secretion of the initial lesion or chancre, from the secretion of any open lesion during the secondary or active period of the disease, most commonly from the secretion of a chancre or of a papule situated upon a mucous membrane—the so-called mucous patch—or from a moist papule situated at a mucocutaneous junction, or from the blood of an individual during the active or contagious stage of the disease. The normal secretions of the body—the tears, the saliva—are not contagious; the semen may infect the ovum. It is believed that the blood is much less contagious than the secretion from an open syphilitic sore. The late or tertiary lesions of syphilis may not be contagious. Inoculation is effected through a solution of continuity of the epithelial covering of the skin or mucous membrane. Such a lesion may be gross or microscopic.

Modes of Contagion.—Inoculation may be direct or mediate, from the direct implantation of the virus from the body of one individual to that of another, or mediate through the medium of infected articles—surgical or dental instruments, pipes, drinking vessels, razors, towels, toothbrushes, etc. Though the infection occurs in the largest proportion of cases during sexual intercourse, nonvenereal syphilis is very common indeed. Surgeons, obstetricians, hospital nurses, wet-nurses, and others who are frequently brought into contact with the disease in innocent ways, not rarely acquire syphilis, and purely accidental infections are sufficiently common.

The Initial Lesion of Syphilis, Chancre (*Hard Chancre—Infecting Chancre—Hunterian Chancre—Ulcus durum—Hard Sore*).—Following inoculation, no changes are observed at the point where the virus was introduced for a period of from ten to forty days—twenty-one days on the average. The wound or abrasion, if large enough to be noticed, heals in the ordinary way. At the

end of the period of incubation there appears at the point of infection a small papule or patch upon the surface, or a fissure or excoriation, usually single. There may be no raw surface at any time, but simply a little desquamation of superficial epithelium. Moderate redness of the surface is present—usually dull red, coppery red, or purplish red—but scarcely any pain or sensitiveness. Gradually there is developed an infiltration of the thickness of the skin or mucous membrane, which increases in depth and superficial area; sometimes when first noticed, usually within a week from its appearance, there is developed the characteristic induration. This may be nodular and involve the entire thickness of the skin, or quite superficial.

Fig. 117.—Ulcerated Initial Lesion of Syphilis. The hard chancre—Hunterian chancre.

The nodular form is of peculiar cartilaginous hardness, quite insensitive, movable upon the deeper structures when situated in loose skin. When pinched its surface becomes blanched, quite white, and strongly suggests a little button of cartilage. In the more superficial form the induration is best appreciated by lifting the area of infiltration between the finger and thumb and making lateral pressure. The part feels as though a bit of parchment or stiff paper were being grasped. An annular form of induration may exist—a ring of hard infiltration surrounding an area where the normal softness and elasticity of the tissues is preserved.

The epithelial covering may remain unbroken throughout the existence of the chancre and be merely thinned over its center, or more commonly a superficial ulcer forms, usually rounded or oval in shape. The base of the ulcer is very slightly depressed, smooth, and of a color which has been likened to raw ham, or covered with a superficial grayish-white, adherent, soft scab or layer of false membrane. The discharge is small or large in amount, and watery, often lemon-yellow in color. The raw surface bleeds readily. Sections of chancre under the microscope show round-celled infiltration of lymph spaces and thickening of the coats of the small blood-vessels, arteries, and veins. Epithelioid and giant cells are present in moderate numbers.

The induration is of very variable size. It may be no larger than the head of a match or cover a considerable extent of surface and be quite massive—two thirds of the circumference of the prepuce, for example. Chancres vary in appearance and physical characters according to their seat and according to whether they are irritated chemically, mechanically, or infected with pus microbes. A number of forms are commonly described. The ulcus elevatum

FIG. 118.—CHANCRE OF THE CHIN BELIEVED BY THE PATIENT TO HAVE BEEN ACQUIRED BY SHAVING WITH A RAZOR WHICH HAD BEEN USED BY A SYPHILITIC FRIEND. (Author's collection.)

is the ordinary eroded or ulcerated hard nodule in which cell infiltration elevates the sore above the level of the skin. The so-called silvery spot occurs upon the glans penis and meatus; it is at first minute, of a silvery white color; later it enlarges and assumes the ordinary character of chancre. The dry scaling papule is the form already indicated in which erosion does not take place; the surface remains covered with epithelium, and is of a dull-red or coppery color.

ECTHYMATOUS CHANCRE.—In certain chancres necrosis of the indurated area may occur, superficial or total, and separate as a slough, brown or black in color. Pyogenic infection may cause the signs of acute inflammation and a purulent discharge from the raw surface. Treated or untreated, chancres heal and disappear after a variable period; usually the sore is healed in six weeks. The induration may persist for months, or even for years, and the seat of the chancre may again become indurated later in the disease. There may be no scar, or a slight or marked scar, after the chancre disappears, depending upon the presence or absence of erosion or ulceration, and its depth. An infected chancre beneath a tight prepuce may destroy the greater portion of the glans penis. Chancre of the meatus urinarius, glans penis, sulcus coronarius, inner layer of the prepuce, usually show marked induration. Upon the general integument and skin of the body of the penis the induration is less marked,

FIG. 119.—CHANCRE OF THE LOWER LIP. (Author's collection.)

Chancre of the Vulva.—In women, chancres of the *labia majora* may be accompanied by general edema and thickening of the labium, and the specific induration at the site of inoculation may be present or absent. Chancres of the labia minora and fourchette are not usually markedly indurated.

Extra-genital Chancre.—Upon the lip the chancre appears as an elevated, juicy-looking, raw, rounded or oval ulcer, with a granular surface, usually covered by a yellowish-white or sulphur-yellow false membrane of partly dried discharge. The lip may be markedly swollen. The induration is present, but is not of the cartilaginous hardness noted in chancres of the penis. Upon the mucous membrane of the mouth the chancre appears as a superficial ulcer, with reddened edges and a base covered with whitish false membrane.

Fig. 120.—Chancre of the Finger. The white spot upon the ulcerated surface represents powdered calomel which had not been entirely removed when the author took the photograph. In this case the chancre had existed for eight weeks and the general eruption of a papular character had appeared upon the arms, chest, and abdomen. (The author was enabled to take the photograph at Bellevue Hospital through the kindness of Dr. J. C. Ayer.)

Multiplicity of Chancre.—According to Fournier, in three cases out of four chancres are single. They may be multiple. I have seen a chancre upon the penis and upon the lip of the same individual; the two sores appeared simultaneously. Chancres acquired during sexual contact are usually situated upon the genitals. They may occur upon the lips, or within the mouth from kissing, or upon the nipple, eyelid, or some part of the face from direct contact. The margin of the anus, the rectum, the tonsil, the palatine arch, and other situations may be infected through unnatural practices between persons of the same or of the opposite sex. I saw a young man who acquired a chancre of the finger from amorous digital palpation of the vulva of a prostitute. The ways in which extra-genital chancres may be innocently acquired are, of course, innumerable. I have recently seen two cases of chancre of the chin from inoculation during shaving. A reference to the characters of extra-genital chancres will be made under Regional Diagnosis.

Development of Enlarged Lymph Nodes.—During the ten or twelve days following the appearance of the initial lesion the anatomically associated lymphatic

glands become successively enlarged. In chancres of the penis the lymphatics of that organ are sometimes traceable as an indurated cord leading in the direction of the groin. A single gland is first noticeable as a rounded, painless, insensitive nodule in the subcutaneous tissues; the enlargement of the rest of the chain gradually follows, and the glands of the opposite side usually participate. With chancre in the middle line or near the frenum, both groins may be simultaneously infected. Chancres of the rectum and anus are also followed by glandular enlargements of the inguinal glands. The individual glands are seldom very large; they are movable, not adherent to one another nor to the skin; they do not suppurate, unless in the presence of mixed infection. Chancre of the lip and chin or mucous membrane of the mouth or tongue is followed by enlargement of the submaxillary or submental glands, or both; of the fingers—epitrochlear and axillary glands; of the breast and arm—axillary glands; of the eyelid—the preauricular glands. The swelling and induration of the glands following chancres of the face is usually very marked.

Development of Constitutional Symptoms.—From forty to sixty days after the appearance of the chancre, wherever situated, a gradual enlargement of the lymph nodes throughout the body takes place. The postcervical chain is usually palpable, and its enlargement is generally regarded as of diagnostic value; these glands are less often enlarged from causes other than syphilis than the submaxillary and anterior cervical chains.

Differential Diagnosis from Chancroid (*Chancroid: Soft Chancre, Ulcus molle*).—Chancroid is an acute contagious ulcerative inflammatory process, occurring almost exclusively upon the genitalia of men and women, occasionally in other situations: in the rectum, on the general integument from direct or mediate contagion, and upon the fingers of surgeons and obstetricians in rare instances. Ducray and Unna have described a small oval, rod-shaped bacillus constantly present in the discharge and in sections of the base of the ulcer. Culture and inoculation experiments have not as yet proved successful. It is probable that many venereal sores of this variety are caused by ordinary pyogenic microbes received upon a favorable soil. The main importance of chancroid from a diagnostic point of view relates to a clinical differentiation between it and the initial lesion of syphilis. In certain instances both kinds of infection are simultaneously ingrafted upon a single point, and this, for a time, may lead to confusion in the diagnosis.

Characters of Chancroid.—The characters of chancroid are as follows: The period of incubation is short—often only a few hours, seldom more than two or three days. There then appear at the seat of inoculation one or more small red, tender, painful, or itching papules, which rapidly break down in the center and form an ulcer with irregular worm-eaten or punched-out, undermined, inflamed edges, a yellow, sloughy base, and an abundant purulent discharge. The ulcer is painful and sensitive, tends to increase in size and depth, may take on a rapidly progressive sloughing or gangrenous or so-called phag-

edenic character; sometimes destroys the tissues quite widely. New sores may be produced by autoinoculation. Chancroid is usually accompanied by painful acute inflammatory enlargement of the lymph glands of the groin. The gland or glands are tender and painful. Moderate septic fever is not uncommon, and the glands frequently undergo suppuration and form a considerable tumor in the groin, which infects and finally perforates the skin and discharges pus.

The Chancroidal Bubo.—Numerous glands are often infected, and the walls of the abscess and the skin overlying it undergo, under favorable conditions, the same progressive ulcerative destruction which characterized the original sore. Such a process may extend indefinitely, involve both groins, the scrotum, perineum, anus, rectum, etc. In alcoholic, underfed, and neglected cases I have seen fatal septicemia follow a chancroidal bubo in more than one instance.

Differences from Chancre.—The main points of difference between chancre and chancroid are as follows: Chancroid has a very short period of incubation or none at all; chancre a period of incubation rarely less than two weeks, average twenty-one days. Chancroid is an acute inflammatory process from the start, characterized by progressive ulceration; chancre is essentially a specific hyperplasia; the signs of acute inflammation are absent. Destruction of tissue, if it occurs at all, is very slight, unless caused by mixed infection or unusual local or general conditions—confinement of discharges beneath a tight prepuce, mechanical or chemical irritation, etc. The discharge from a chancre is watery and thin; that from a chancroid is distinctly purulent. The *induration* of typical chancre is of cartilaginous hardness and sharply circumscribed; chancroids show either no induration or, if present, the hardness shades off into the surrounding tissues, and is rarely, if ever, of a cartilaginous quality. The adenitis of chancre is discrete, painless, not followed by suppuration; the adenitis of chancroid follows the course of ordinary pyogenic infection of lymph nodes. Periadenitis and matting together of the tissues forms a large inflammatory mass. Suppuration does not occur in the adenitis of a purely syphilitic infection; the adenitis of chancroid quite commonly ends in suppuration. Lastly, chancre is followed in most cases by general adenitis and characteristic eruptions upon the skin and mucous membranes; chancroid is not. In the cases of mixed infection, chancroid follows immediately after coitus, and either heals or continues as a chancroidal ulcer. After the period of incubation of syphilis has passed, the site of the healed or unhealed chancroid becomes indurated and the individual goes on to develop constitutional syphilis.

Differential Diagnosis from Herpes of the Genitals.—Herpes of the prepuce, of the glans penis or meatus urinarius, and of the muco-cutaneous junctions upon the vulva of the female, is an exceedingly common disease. The lesion consists of one or more small vesicles situated upon a slightly inflamed and reddened base. Subjective sensations of burning and itching precede and accompany the formation of the vesicles. The lesions are frequently multiple.

Herpes occurs quite independently of sexual contact, although the mechanical irritation of coitus sometimes causes an attack. The disease seems often to depend upon digestive and neurotic disturbances. One attack is often followed by others at irregular intervals, and in some individuals such attacks may occur every now and then, whether they have coitus or not. The appearance of vesicles is preceded in most instances by subjective sensations of itching and burning for several hours or a day.

Upon inspection one or more small patches of slightly reddened skin may be observed. If a magnifying glass is used, it is sometimes possible at this time to see a group of six, eight, or more minute vesicles upon the red area; the whole patch may be the size of a match head, or rarely as much as a quarter of an inch in diameter. After a day the vesicles coalesce, and form a delicate pellicle containing a drop of serum and situated upon an inflamed and red base. Several such lesions may form simultaneously or successively. Usually the vesicle is ruptured mechanically in a few hours, leaving a superficial red, moist, excoriated surface, from which a slight serous discharge escapes. The base of the excoriation shows no induration and the inflammatory infiltration is entirely superficial. When let alone, and not infected or irritated mechanically or chemically, the surface dries and heals in from three days to a week, leaving behind a small red, superficial spot, which disappears in a few days more. When infected or irritated mechanically or chemically, the appearance of the lesion may be entirely changed and confusion in diagnosis may easily arise. In these cases time will render the diagnosis clear.

Diagnosis of Syphilis in the Early Stages of the Disease.—The diagnosis in the early stages of syphilis is a matter of such grave importance to the individual, and may so seriously affect the present and future conduct of his life, that the surgeon should be very sure of his ground before pronouncing a positive opinion in the given case. Among intelligent people, the belief or knowledge that they are infected with syphilis causes a degree of mental anguish which is often pitiable. The inauguration of vigorous antisyphilitic treatment, a hateful and depressing thing in itself, may, if no general symptoms develop, leave the individual in a state of doubt and uncertainty harder to endure, perhaps, than the disease. It therefore behooves us to be cautious in the extreme, and by no means to condemn the patient to several years of physical discomfort and some degree, at least, of mental distress until we are quite certain that syphilis exists.

The following considerations may not be unworthy of consideration: Any abrasion, herpetic vesicle, or sore of any sort following a doubtful coitus should be viewed with some degree of suspicion, and kept under observation until the period of incubation of syphilis is past. Any sore which appears ten days or more after such a coitus is decidedly suspicious; if the base of the sore gradually assumes a characteristic hardness it is probably a chancre. If, during the following fortnight, the associated lymph nodes slowly and painlessly enlarge, the diagnosis of syphilis is almost certain. Should it now be possible to examine the woman with whom the exposure occurred, and should she be found suffering

from active syphilis with infecting lesions, the diagnosis is confirmed. Assume, however, that no such confrontation is possible, that the sore has been chemically or mechanically irritated or is a little infected with pyogenic organisms, the induration may be never so characteristic, the glands of the groin may become enlarged, and yet the patient may not have syphilis at all. He should be kept under observation. If he has syphilis, general glandular enlargements and eruptions upon the skin and mucous membrane will occur in due season, and he may then be got under the influence of mercury as speedily as possible.[1]

Among women, the diagnosis of genital chancres is less commonly made during the early weeks of the disease than among men. They are less apt to seek early medical advice, and the sore, being painless and often hidden from their direct vision, does not so early attract attention. Chancre of the cervix uteri may escape notice entirely.

Extra-genital Chancres.—Extra-genital chancres are apt to be regarded as simple lesions for a time, but they soon take on a definite character, and are associated with characteristic glandular enlargements. Chancres upon the scalp, supra-orbital region, chin, and cheeks form a rounded, elevated, raw surface, covered by a yellow membrane or scab. This being removed, the surface is glazed or granular, of a rather pale-red color, bleeding easily. Induration of the base is fairly marked in some cases, less so in others. The appearance is always suggestive of a sluggish chronic process. Chancres of the lip and of the mucous membrane of the mouth and throat are more apt to arouse immediate suspicions of their nature because of the frequent occurrence of initial lesions in these regions. Chancre of the lip is occasionally mistaken for epithelioma. The differences are as follows:

Differences from Epithelioma.—Chancre may occur at any age and on either lip. Epithelioma occurs on the lower lip, usually in elderly men who have habitually smoked a pipe. It is very rare in women. The development of chancre takes place in a few days or weeks, and ceases to grow larger. Epithelioma is usually very slow in development, but continues steadily to increase in size. The lymph glands are enlarged almost at once in chancre, not as a rule for months in epithelioma. The appearance of the raw surface may be rather similar if covered by a soft scab, but the epithelial pearls and columns can often be expressed from the surface of an epithelioma; no such structures exist in chancre. The sulphur-yellow crusts of chancre are wanting in epithelioma. In cases of doubt, a small portion of excised tissue placed under the microscope establishes the diagnosis, positive or negative, of epithelioma at once. The chancres of the interior of the mouth begin as abrasions, excoriations, or papules, which soon become covered with a white or grayish-white false membrane. Their failure to heal under ordinary treatment, the enlargement of lymph glands, and sometimes the history, aid in the diagnosis.

Chancres of the tonsil and pharynx are usually very painful. Chancres

[1] It is here assumed that facilities for the identification of the Spirocheta pallida are not at hand.

of the nipple begin as fissures, excoriations, or papules; they soon become juicy-looking, elevated, red raw surfaces. The axillary glands become swollen. If transmitted by nursing, examination of the infant will usually reveal mucous patches of the mouth. Chancre of the finger often begins at the side of the nail, and resembles an ordinary paronychia. The induration, the slow and chronic course, and later symptoms establish the diagnosis. On the dorsum of a finger an elevated, rounded, raw, and juicy-looking papule is produced; the raw surface in these cases often reaches a considerable size, so that the greater part of the dorsal surface of a phalanx may be involved. Induration is not marked (See illustration.)

Secondary Symptoms, Secondary Syphilis.—Six or eight weeks after the appearance of the initial lesion the so-called secondary symptoms of syphilis may be expected to appear. They consist of slight or moderate fever, usually of brief duration, often of headache, which may be severe and worse at night, and of neuralgic pains in the muscles, bones, and elsewhere; these pains also are nearly always worse at night. The fever and pain may be absent or may precede or accompany the cutaneous eruption.

The Blood.—A slight or moderate diminution in the number of red cells of the blood has been noted in the early secondary period of syphilis. Diminution in the content of hemoglobin regularly occurs. This anemia becomes more marked as time goes on, and in severe or untreated cases may reach a high grade. The anemia is improved by the proper use of mercury, and is rendered worse by mercurial poisoning. In the tertiary stage with severe symptoms the anemia may reach a profound degree. A moderate leucocytosis accompanies the anemia, and usually varies with it; as the anemia passes away under treatment, the leucocytes also diminish in number.

The Typical and Characteristic Diagnostic Signs of Secondary Syphilis.—The typical diagnostic signs of secondary syphilis consist of a series of eruptions appearing upon the skin and mucous membranes, together with affections of the appendages of the skin, the nails, and the hair, sometimes of inflammations of the iris, the joints, etc. The skin eruptions consist of *macules*, *papules*, and *pustules*. These lesions are characterized by a rather chronic course, by absence of pain and itching, by a more or less characteristic distribution, and by a tendency to arrange themselves in groups, segments of circles, circles, and figures of eight. The different types of lesion—macules, papules, pustules—often exist side by side; this so-called polymorphism is strongly suggestive of syphilis. The lesions occur in crops; successive outbreaks come at irregular intervals. The earlier eruptions are usually superficial; the later outbreaks tend to invade the entire thickness of the skin, to be of a more limited distribution, to run a more chronic course, to be more destructive, and to leave permanent scars.

The Macular Syphilide, Syphilitic Roseola.—The macular syphilide —syphilitic roseola, syphilitic erythema—usually the first eruption to appear, consists of rounded or irregularly shaped spots upon the skin, varying in size from a pin's head to an inch in diameter; they are not elevated, nor do they

produce a palpable infiltration. In color they vary from pale pink to red and even purple. The eruption is often quite evanescent. It may sometimes be made to appear by exposing the skin to cold air or rubbing the surface of the body with alcohol; sometimes the eruption is general, often it appears first

Fig. 121.—Maculo-papular (Polymorphous) Syphilid. (Fox.)

on the abdomen, then upon the chest, upper and lower extremities, and face, in the order given. This anatomical order is true also of the appearance of the papular eruptions.

The Papular Syphilide.—The papular syphilide occurs with or after the roseola. Papules are circumscribed infiltrations of the skin. They may be large or small, and vary in character according to their anatomical situation. They may be dry, or dry and scaly when the epidermis is normally dry and thick, notably on the palms and soles, or moist and juicy where the folds of skin are in contact — scrotum, labia majora, margin of anus, beneath the breasts, etc. The small papules, known as miliary papules, are conical rounded ele-

vations of the skin, varying in size from a pin's head to a quarter of an inch in diameter. They are pale red or red in color when recent, and assume a coppery tinge when old. They are often scaly or possess scaly borders (papulo-squamous syphilide); *they are to be distinctly felt by the finger.* If compressed, the red color disappears, but leaves a brownish or copperish stain behind. They occur over the general cutaneous surface, rarely upon the dorsum of the hand. Upon the forehead, just below the line of the hair, they may

Fig. 122.—Papular Syphilid: Confluent on Face. (Fordyce.)

form a grouped eruption, and are here known as the *corona veneris.* The larger papules may be an inch or more in diameter; in character they resemble those just described. Untreated, syphilitic papules run a chronic course, and may remain for many weeks; gradually the infiltration disappears, leaving a very characteristic coppery pigmentation behind, one of the surest diagnostic signs of syphilis.

Flat Condylomata—Moist Papules.—As noted, papules assume a moist elevated character when they occur at muco-cutaneous junctions, or where

two skin surfaces are in contact. Confluent groups of such papules in these situations are known as *condylomata lata*; they may form considerable tumors, and may be mistaken for epithelioma. They are often excoriated, covered by a false membrane, and, if neglected, the discharge from them becomes offensive. The smaller papules are sometimes spoken of as *mucous patches* in these situations. Untreated, they may last for many months. A distinctive character of papular syphilides is their occurrence upon the palms of the hands and soles of the feet.

Papules upon Mucous Membranes, Mucous Patches.—In the mouth, upon the tongue—upon its tip and lateral borders—at the angles of the mouth, the mucous membrane of the cheeks, upon the tonsils, the pillars of the fauces, and the palatine arch, mucous patches are regularly present at some time during the secondary period of syphilis. They are highly contagious lesions, and from their situation are a frequent source of contagion. They form small, rounded, or large plaques upon the surface of the mucous membrane, surrounded by a narrow red areola or a diffuse congestion. The mucous membrane may appear as though painted with nitrate-of-silver solution, or be covered with a grayish-white false membrane. They are easily healed lesions, but recur with pertinacity from slight causes of irritation, notably from the use of tobacco and alcohol. They may be moderately painful.

The Nails, Onychia.—Papules occur along the borders of the nails. The nutrition of the nail itself may be affected, the nail becomes dry, brittle, and deformed. In some cases a low grade of suppuration occurs around the base and matrix of the nail. The nail becomes thinned and broken, a thin or purulent discharge exudes from beneath the base of the nail and from the matrix. The nail turns brown or black in some instances, and may be lost. One or many nails of the fingers and toes may be affected.

The Pustular Syphilides.—The early occurrence of this form of eruption is thought to indicate a grave form of the disease. Three types are described: Syphilitic acne, Syphilitic impetigo, and Syphilitic ecthyma. These lesions are of a mild or severe ulcerative character. Syphilitic acne is often on the borderland between a papule and a pustule. They form small conical projections, a little serous effusion occurs, which rapidly dries into a scab or crust. They disappear without scarring. The eruption is generalized, may be confluent in some regions, notably upon the thighs and abdomen, where ordinary acne is rare. The crusts and coppery stain after the crust separates are characteristic. Papules and papulo-squamous syphilides often coexist. Syphilitic impetigo—localization chiefly face and scalp. A pustular eruption covered by crusts, may be confluent, when large areas may be covered with adherent scabs. A copper-colored stain remains. Syphilitic ecthyma—the lesion is a superficial or more deeply destructive pustule of considerable size. It may begin as a bleb upon an inflamed base, which soon becomes converted into a large pustule. The pus dries and is converted into a black crust. This may separate, leaving merely a dark stain without scarring, or ulceration, deep or

superficial, may occur with scarring. The lesions are circular in shape. The scars are at first pigmented, and later turn white. They are common upon the lower extremities. They are sometimes disseminated and sometimes

FIG. 123.—SQUAMOUS SYPHILID OF PALM. Note circinate border and absence of definite papules. (Fordyce.)

grouped. The circular shape of the scars is characteristic. Multiple circular white scars upon the legs thus become of diagnostic value in distinguishing gummata and other late lesions from new growths, etc.

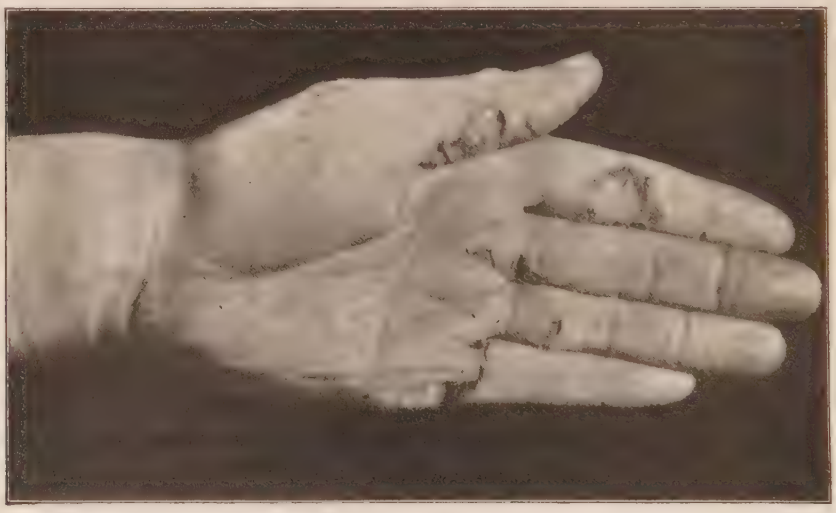


FIG. 124.—FISSURED AND ULCERATED ECZEMA OF PALM, SIMULATING AN ULCERATING SYPHILID. (Piffard.)

RUPIA.—Rupia is of similar character, but larger size, and attended by deeper ulceration than ecthyma. Rupia begins as a bleb upon an inflamed base, circular in shape, beneath which ulceration of the skin takes place. The crusting is excessive. The crusts are black. They continue to be piled up

from the discharge of the ulcer until they form a conical mass of considerable size. The entire thickness of the skin is destroyed. Scarring and pigmentation result.

Plantar and Palmar Syphilides.—The lesions above described constitute the majority of the cutaneous accidents which occur during the first year or two of syphilis. They may appear, however, usually in a discrete form and often as solitary lesions, very late in the disease. This is notably true of the plantar and palmar papulo-squamous syphilides which may appear after many years of apparent cure, and are the most intractable of syphilitic lesions of the integument. I have recently had two cases under my care. In one, sixteen years had elapsed since the infection, and the occurrence of round, scaly, dull red patches upon the palms, varying in size from a quarter of an inch to three quarters of an inch in diameter, associated with cracks and fissures in the skin, where normal cutaneous folds existed, were the first late lesions this patient developed, though I have had him under observation for ten years. The second case has been under my care with locomotor ataxia for seven years. Infection twenty years ago. The palmar and plantar syphilides first appeared about a year ago. In passing, I may remark that daily calomel fumigations caused the lesions to disappear.

Fig. 125.—Tubercular Syphilid of the Buttocks. (New York Hospital, Out-Patient Department.)

Tubercular Syphilides and Gummata.—The later cutaneous lesions of syphilis are known as tubercular syphilides and gummata. The lesions are similar, but the first is confined to the skin; the second involves the skin, the subcutaneous tissues, and deeper structures. They usually occur after two years or more, sometimes earlier. Tubercular syphilides consist of elevated infiltrations of the entire thickness of the skin, usually of considerable size, single or multiple, discrete or confluent. Their favorite situations are the face, the back, the neck, the lower extremities, and the muco-cutaneous junctions. When confluent, the lesion may cover large areas. They are red, later copper-colored, and soon become covered with thick scales. They may disappear in time without ulceration, but leave behind a scar, at first pigmented, then white, circular,

or with wavy, rounded borders. The lesion is a very chronic one. Tubercular syphilides sometimes ulcerate; the lesion then becomes covered by a crust, and furnishes an abundant purulent discharge. This is commonly a very chronic lesion.

Gummata of the Skin.—As stated, gummata belong to the later periods of the disease. When they occur during the first year, they are thought to indicate a grave form of syphilis. The gummatous process consists essentially of a dense, small-celled infiltration and the production of a kind of tissue resembling granulation tissue, but poorly supplied with blood vessels, and prone to undergo necrosis *en masse* with the production of a soft, yellowish-white, gelatinous, semisolid, gummy material, from which the lesion derives its name. They may occur as localized infiltrations and tumors of varying size in almost all the tissues of the body. In the skin and subcutaneous tissues they frequently occur as slowly growing, painless, insensitive nodules attached to the skin or movable beneath it. Under treatment they may disappear without ulceration. More commonly the tumor gradually softens, the skin becomes reddened, fluctuation develops, the skin is perforated, a little pus and gummy material is discharged. The edges of the ulcer are mildly red, circular in outline, undermined. The ulcer is deep, covered with a yellowish-white, necrotic, adherent, soft material; later on by pale red, unwholesome granulation tissue. If untreated, the ulcer is extraordinarily sluggish and may remain open for months or years.

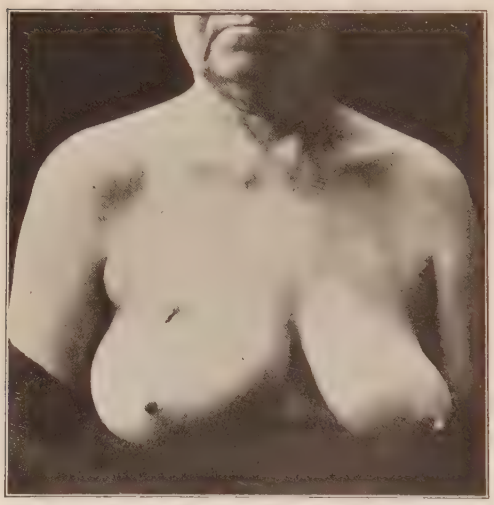


Fig. 126.—Ulcerated Gumma of the Breast. (Author's collection.)

Ulcerating gummata, as well as all the other more deeply seated syphilitic lesions of the skin, sometimes take on what is known as a *serpiginous character*—that is to say, the process of infiltration and degeneration advances slowly in an irregular manner, while the older portions of the lesion heal; thus, a rounded or wavy outline of scar tissue is found in one place, a partly healed ulceration in another, and a recent and advancing process in a third. The scars of gummata are less pigmented, and sooner assume a white color than do the earlier lesions of syphilis.

Some of the chronic ulcerative lesions resemble ulcerative lupus; the characteristic appearances of tubercular granulation tissue are wanting, as well as the translucent "apple-jelly" like nodules. In cases of doubt the administration of mercury and of large doses of iodid of potash, or the microscopic

examination of a portion of excised tissue, will make the diagnosis certain. The scars of former ulcerative syphilitic lesions are smooth, circular, or rounded. The scars of lupus are irregular in shape and of a puckered uneven surface.

Cutaneous and subcutaneous gummata are frequently multiple. They may appear upon any region of the body. A diagnostic point in all the syphilitic lesions of the skin is their painlessness, and the general want of those subjective sensations, such as burning, itching, and the like, which commonly accompany lesions of equal gravity from other causes. A further discussion of the differential diagnosis of syphilis of the skin and mucous membranes from other conditions will be found in the chapters on Regional Surgery.

Syphilis of Muscles.—A word in regard to syphilis of the muscles; gummatous infiltration occurs with moderate frequency. The infiltration may be circumscribed or diffuse, and may form a tumor of considerable size in the muscles of the extremity or trunk, not infrequently, really or apparently, adherent to the bone. The affection simulates quite closely sarcoma of rather a firm consistence; many unnecessary operations and amputations have thus

Fig. 127.—Syphilitic Arthritis of the Elbow. (Collection of Dr. Charles McBurney.)

been performed. Unfortunately, even a microscopic examination does not render the diagnosis absolutely clear in every case. Clinically, gummata often occur as multiple tumors in the same or in different muscles; sarcoma is usually single. Gumma, if it grows rapidly, may be painful and tender. It is more often found near the tendon than in the middle of a muscular belly. If the gumma breaks down and penetrates the skin the diagnosis is simplified. Gumma does not tend to grow beyond certain definite proportions; sarcoma grows indefinitely. A history of syphilis and large doses of iodid of potash aid in the diagnosis.

Syphilis of the Bones.—(See Diseases of Bones.)

The syphilitic affections of the brain and spinal cord have no direct relation to surgical diagnosis. (See Brain and Spinal Cord.) Syphilis of the liver, testis, and other organs will be mentioned in the chapters on Regional Surgery.

Hereditary Syphilis.—There is no initial lesion in hereditary syphilis. The symptoms of the disease may appear soon after birth, or be deferred for a number of years. The child may be born dead, or with marked signs of serious lesions, such that it is not viable. More commonly, the symptoms do not appear for several weeks after birth. Prominent symptoms are coryza; a hoarse cry and a pemphigus eruption upon the skin. Large blebs filled with serum, which becomes purulent, form on various regions. Erythema, papules, changing later into pustules, mucous patches in the mouth, and broad condylomata about the genitals are common. The liver is frequently enlarged. The inflammation of the epiphyses of long bones at their junctions with the shafts has already been described. (See Diseases of Bone.) Iritis and keratitis are not uncommon.

Syphilitic Teeth.—A peculiar deformity of the permanent, upper middle incisor teeth is frequent, and is regarded as diagnostic of hereditary syphilis. The teeth are shorter than normal, narrower at the cutting edge than at the base of the tooth, crescentically notched along their cutting edges, the convexity of the curve directed toward the base of the tooth, and beveled at the expense of the anterior surface—"Hutchinson's teeth." (For further details, see Regional Surgery.)

LEPROSY

Leprosy is a chronic infectious disease caused by the growth in the tissues of a small rod-shaped bacillus—the Bacillus leprae. The disease is contagious in the sense that persons who live in close contact with leprous individuals are almost sure to acquire it if they continue among such surroundings for a period of years. The period of incubation is long, sometimes four or five years. The disease is characterized by the production of brownish-red spots and nodules in the skin, and in some cases by chronic inflammation and thickening of the peripheral nerves. The bacilli closely resemble those of tuberculosis, both in shape and staining reaction. They are found chiefly in the cell protoplasm of the round cells found infiltrating the connective tissue of the leprous nodules, and in the scrapings and discharges from leprous ulcers. They may be stained by Gram's method or with carbol-fuchsin, using a weaker sulphuric acid for decolorizing than is used for tubercle bacilli, for lepra bacilli are more rapidly bleached by the acid. They have rarely been cultivated outside the human body, and inoculation experiments in animals have usually failed. One successful inoculation in man upon the body of a condemned criminal was made by Arning. A moderate number of cases of the disease exist in restricted areas of the United States, but the cases seen here are most of them imported

from Asia, Scandinavia, and other countries where the disease is endemic. In the Sandwich Islands the disease occurs, and the lepers are segregated and isolated in the island of Molokai.

Forms of Leprosy.—Two forms of the disease are described—the tubercular and the anesthetic—according to whether the skin or the nerves are chiefly involved.

Tubercular Form of Leprosy.—In the tubercular form the lesions appear chiefly upon the face, the hands and feet, and the extensor surfaces of the elbows and knees; but may occur almost anywhere upon the body, except the scalp, the palms, and the soles. Preceding the appearance of nodules there occur upon the skin spots of pigmentation, brown, brownish-red, or dark brown in color, varying in size from half an inch in diameter to several inches. These spots may appear and disappear several times before the nodules develop. The nodules usually occur upon a spot previously pigmented, but may begin elsewhere. They are rounded or flat, pink, or yellowish-brown soft prominences, varying in size from that of a pea to that of a walnut. Coalescence of the nodules forms plaques of various sizes and shapes, such that upon the face they produce extraordinary and hideous distortion of all the features (leonine leprosy). The tubercles may be absorbed or break down and form shallow indolent ulcers; occasionally the ulcerative process is rapid and destructive. Ulceration of the nodules is said to be more common upon the extremities than upon the face. Similar lesions occur on the mucous membranes of the nose, mouth, and throat. The duration of life is indefinite. The patients may die of phthisis, nephritis, pneumonia, dysentery, or some other intercurrent disease.

Anesthetic Form of Leprosy.—This form of leprosy usually begins with a skin eruption in the nature of blebs or spots of erythema; these spots are hyperesthetic at first, later they become anesthetic. The affected nerve trunks—the median, the ulnar, for example—increase in size, and, in advanced cases, may form cords as thick as a cigarette or thicker. The ulnar nerve is frequently involved, and can be felt enlarged and thickened behind the internal condyle of the humerus. The nerve is sensitive in the early stages of the disease; there is analgesia, but in the earlier stages no total loss of tactile sensibility. Affections of the cranial nerves produce facial paralysis with inability to close the eyes. The analgesia of the extremities leads to the continued unconscious receipt of mechanical and thermal insults leading to ulcerations and ultimate mutilations. Perforating ulcer of the foot is a common occurrence. Muscular paralysis occurs in the affected nerves of the extremities, and leads to atrophy of groups of muscles and to characteristic deformities. Gangrene and spontaneous amputation are common in the fingers and toes.

Tubercular leprosy may be confounded with syphilis, prolonged observation of the case would make the diagnosis clear. The negative effect of mercury in leprosy and its very rapid curative effect in syphilis would furnish an

ample means of differentiation. Excision of a nodule or scraping of a leprous ulcer would furnish means for identifying the numerous leprous bacilli under the microscope. The history of exposure to leprosy, of course, is important. (For the differential diagnosis between leprosy and various skin diseases the reader is referred to works on dermatology.)

CHAPTER X

DISEASES OF BLOOD-VESSELS

ANEURISM

An aneurism is an abnormal dilatation of an artery forming a cavity through which blood from the artery circulates. Aneurism may result from disease of the vessel wall, atheroma, endarteritis syphilitica, or other degenerative change, or from injury—stretching or tearing of one or more of the arterial coats, or from an open wound of the vessel. As the result of disease a uniform dilatation of some limited section of the arterial wall, including its entire circumference, leads to an aneurism of cylindrical or fusiform shape—cylindrical aneurism or fusiform aneurism. If the arterial wall gives way or becomes dilated over a limited area not involving the entire circumference of the vessel a sac is formed of greater or less size, communicating with the caliber of the vessel more or less freely, through a comparatively narrow orifice—*sacculated aneurism.* Many sacculated aneurisms are due to traumatic and mechanical causes. When an aneurism bursts subcutaneously and blood is extravasated more or less widely into the surrounding tissues the condition is known as *diffuse aneurism* or *secondary aneurismal hematoma.* A direct wound of an artery, or its rupture by direct violence, followed by the formation of a tumor composed of clotted and fluid blood, is also sometimes called diffuse aneurism, or *arterial hematoma,* or *primary aneurismal hematoma.* A wound which involves simultaneously an adjacent artery and vein may lead to a permanent abnormal communication between the artery and the vein. If the communication is close and immediate, the condition is known as *aneurismal varix.* If a sac forms between the artery and the vein and communicating with both, the condition is known as *varicose aneurism.* Both types are included under the general title of *arterio-venous aneurism.* When the internal coat of an artery gives way and blood finds its way along the substance of the middle coat, or between it and the outer coat, the condition is known as *dissecting aneurism.* It occurs only in the aorta, and is of no surgical interest. The cylindrical, fusiform, and sacculated dilatations of arteries, as well as those injuries of arteries followed by the escape of blood from the artery and its accumulation in the surrounding tissues, with the formation of a cavity whose walls are composed of the tissues displaced by arterial blood-pressure and lined by connective tissue, fibrin, and blood-clot, and filled with fluid blood

communicating directly with the caliber of the wounded vessel, form a group of conditions usually known as *circumscribed aneurism*. *Cirsoid aneurism* has already been described under the head of Tumors.

Symptoms of Aneurism.—The subjective symptoms accompanying aneurism are due chiefly to its increase in size, whereby it causes pressure upon nerve trunks, bones, veins, interference with hollow canals, or organs, etc.; and these symptoms will, of course, vary with the size and situation of the aneurism. Aneurisms in the extremities cause more or less pain, sometimes of a dull and aching character; sometimes sharp and neuralgic; sometimes muscular weakness, limitation of motion in joints, as, for example, in the knee-joint in popliteal aneurism. By pressure upon veins, edema and congestion of the extremity may occur. Intrathoracic aneurisms may, by pressure upon the innominate vein, cause attacks of sudden and intense venous congestion of the face and neck, with giddiness, or dyspnea from pressure upon the trachea, or difficulty in swallowing from pressure upon the esophagus. A further growth of the aneurism may cause paralysis of nerve trunks by pressure, a change in the voice by pressure on the recurrent laryngeal nerve.

Physical Signs.—The physical signs of circumscribed aneurism are, the existence of a smooth, rounded, sharply-circumscribed, rather soft, fluctuating, elastic, and pulsating tumor situated over the course of an artery. The size of circumscribed aneurism varies from an inch to three inches in diameter, rarely more, except those of the aorta. The tumor is readily compressible, but returns immediately to its former size as soon as the pressure is relieved. The pulsation of aneurism is peculiar in that if the tumor be deeply grasped with the fingers they may be felt and seen to separate a little with each pulsation, and the expansion is felt on both sides alike—"expansile pulsation." By auscultation over the aneurism a soft or harsh blowing murmur can usually be heard synchronous with the pulsation.

If the main artery be compressed between the aneurism and the heart, pulsation in the aneurism as well as the murmur cease, and the tumor, if the aneurism is of recent formation, may diminish in size or disappear. Pressure upon the affected artery distal to the tumor causes the aneurism to increase in size. The pulsation in arteries distal to the aneurism is usually weaker than on the sound side of the body, and delayed, as can often be demonstrated by sphygmographic tracings of the two vessels, or by comparing the characters of the pulse on both sides of the body at the same time, a finger being placed on each. If the aneurism is deeply placed, so that it cannot be easily palpated, some or all of these signs may, of course, be wanting. In old aneurisms the sac may be greatly thickened by deposits of fibrin, and the opening into the vessel may be small. The signs of pulsation and murmur may then be greatly obscured or absent. The aneurism may have undergone consolidation and spontaneous cure. A solid tumor connected with the artery will then be present. In cases of subcutaneous rupture of aneurism the signs of swelling and inflammation may entirely overshadow or completely hide the signs of

aneurism itself; later, a secondary sac may form in which pulsation and bruit may develop.

Pyogenic infection and suppuration of an aneurismal sac is a rare and grave accident, it is attended by general symptoms of sepsis, fever, often a chill, a rapid pulse, prostration, etc. Locally, the signs of acute inflammation are present in the tissues covering the aneurism, the pulsation and bruit may cease. Pain is a very marked symptom. Pressure upon the veins may cause their occlusion, with swelling and edema of the limb. Thrombosis of the artery is not an uncommon complication, and the combined interference with the arterial and venous circulation often leads to gangrene of the limb. In other cases an abscess forms in and around the aneurism which may perforate the skin, burst, and be accompanied by dangerous or fatal bleeding.

Fig. 128.—Aneurism of the Common Femoral Artery in Scarpa's Triangle. (New York Hospital collection.)

Mild noninfectious inflammation, with swelling, edema, redness, and tenderness of the overlying skin, is not uncommon during the growth of an aneurism. It may be accompanied by clotting of the blood in the sac and cure of the aneurism. The growth of the intrathoracic aneurisms is often attended by absorption of bone by pressure—the sternum, the ribs, the vertebræ. Deep-seated abscesses of the anterior thoracic wall should always be regarded as possible aneurisms. A careful examination should be made for pulsation and bruit.

Course of Aneurism.—The ordinary course of aneurism is toward final rupture; when this takes place into the large body cavities, the pleura, pericardium, peritoneum, sudden or speedy death is the rule. Aneurisms which burst outwardly cause first a thinning and discoloration of the skin, later necrosis. The rupture may be through a large orifice and cause rapidly fatal bleeding, or through a small one, which may be plugged by a clot after a greater or less quantity of blood has escaped. Bleeding is, however, sure to recur, and will be fatal unless the vessel can be ligated, or Matas' operation be done.

Diagnosis.—The diagnosis of aneurism in its earlier stages, when so placed that it is readily accessible to examination, is absolutely simple, the signs are characteristic and resemble no other lesion. When inaccessible to palpation, they may pass unrecognized or be recognized with difficulty. When the sac has become greatly thickened by the deposition of laminated blood clots, the characteristic signs may be wanting, or so faint as not to be detected. Such aneurisms may be mistaken for solid tumors, for cysts, or for abscesses. I have seen an aneurism of the external iliac, which presented in the groin as a fluctuating swelling covered by red and inflamed skin, diagnosticated as a suppurative inguinal adenitis by an experienced surgeon. Any tumor or apparent abscess which overlies the course of a large artery should be examined with great care for the signs of aneurism.

The mistake of supposing that a tumor of any sort overlying a large arterial trunk is an aneurism may easily be made; this is due to the fact that such tumors may exhibit a pulsation transmitted to them by the artery. The pulsation of such tumors is not expansile, but if the examining fingers cannot be pressed into the tissues far enough to grasp the widest portion of the tumor, the sensation transmitted may be that of expansile pulsation, because as the tumor is lifted by the artery it may be pressed up between the fingers as a wedge, thus separating them. If the tumor can be pushed to one side of the artery, or lifted away from it, the pulsation will cease. The tumors most likely to be mistaken for aneurism are the very vascular sarcomata and carcinomata; they also may exhibit expansile pulsation, but they are rarely so soft as to give the sensation of fluctuation, nor can they be diminished in size by pressure to the same extent as an aneurism, nor do they suffer the same diminution in size when the main artery of the limb is compressed.

ARTERIO-VENOUS ANEURISM

Arterio-venous aneurism signifies an abnormal communication between an artery and a vein. The condition arises most often as the result of a wound which opens the artery and the vein at the same time. In some cases a rupture of an aneurism may take place into a vein, and in still others it appears that the aneurism has occurred spontaneously from disease of the arterial and venous walls.

During the days when venesection was largely practiced the unskillful use of the lancet at the bend of the elbow and the simultaneous wounding of a vein and of the brachial artery produced in a good many cases an arterio-venous aneurism. At the present time they are rare in this situation, but occasionally occur as the result of stab wounds and bullet wounds which accidentally wound an artery and a vein. They may rarely be due to fractures, and occur in fractures of the base of the skull, from an edge of bone which wounds at once the internal carotid artery and the cavernous sinus.

The spontaneous variety usually arise in the aorta; sometimes the com-

munication is with the pulmonary vein, or in the abdominal aorta with the vena cava. In the traumatic variety the opening in the artery may lead directly into the vein, or there may be formed an intermediate aneurismal sac between the vessels—aneurismal varix and varicose aneurism respectively. The aneurismal sac, if one be present, may be formed of connective tissue, or from the wall of the dilated vein itself.

Signs and Symptoms.—The signs and symptoms produced will vary in severity according to the relative size of the artery and of the vein. If the artery be small and the vein large, so that it can readily dispose of the additional flow of blood, the symptoms may be slight or absent. If the artery is large and the vein small, the vein and its branches become enlarged, varicose, and tortuous on the distal side of the abnormal opening, and serious and even grave disturbances of the circulation and nutrition of the part may follow.

When due to an open wound, the symptoms are usually not long in making their appearance. The wound often bleeds freely, but the hemorrhage is usually controllable by pressure. The wound in the skin heals in the ordinary way, and usually after a short time the *characteristic sign* of this form of aneurism is noticed—the so-called *thrill.* The thrill can be felt by placing the hand over the seat of the injury. A murmur can be heard by placing the ear or a stethoscope over the opening between the artery and the vein, and usually for some distance above and below that point. The thrill is continuous, and has been likened to the purring of a cat, the noise made by a bluebottle fly when buzzing in the interior of a thin paper bag, and to other similar vibratory phenomena. The murmur also is continuous, with rhythmic changes in intensity corresponding to the pulsations of the heart. In addition there may be swelling of the limb in the neighborhood of the wound, dilatation of the superficial veins, or the formation of a definite, circumscribed tumor which gives the sign of expansile pulsation, indicating the formation of a sac. In the limbs the dilated veins may also pulsate.

The *later progress* of the disease varies greatly. The varicose condition of the veins may increase and become so extensive as to involve most of the superficial veins of the extremity. In other cases the enlargement will be slight. There are sometimes disturbances of sensation in the limb, such as numbness, tingling, and neuralgic pains. The nutrition of the limb may also be disturbed; there may be weakness of the muscles; the limb may be permanently swollen; chronic dermatitis, sometimes with ulceration, may develop upon the skin. In some instances the disease may become stationary; in others it may continue to grow worse, even to the extent of producing a rupture of the aneurismal sac externally.

Forms.—If the artery and the vein are in close contact so that the blood passes from the artery to the vein without any space between, the condition is known as *aneurismal varix.* The vein and all its branches may become enlarged and varicose. If, however, some space exists between the artery and

the vein, and a sac is formed communicating on the one hand with the artery and on the other with the vein, the condition is known as *varicose aneurism.* It is not always possible to distinguish the two forms by external examination, notably if the vessels are deeply seated. The diagnostic signs of the condition are usually present soon after the injury, although some of the results of the abnormal communication only develop gradually after some time has elapsed. As in other punctured wounds of arteries, sharp bleeding may take place at once, and a mixture of arterial and venous hemorrhage has been noted in certain cases; such hemorrhage soon ceases, and the wound usually heals without delay.

Diagnostic Signs.—The diagnostic signs are a thrill, felt when the palm of the hand is placed over the seat of the injury; this sensation is readily appreciated in all cases except where the vessels are very deeply placed. The murmur is readily heard through the stethoscope placed over the site of the wounded vessel. It is usually heard most plainly at this point, and is often a continuous murmur, which is, however, louder during the systolic pulsation of the artery. It may also be heard for some distance above and below the point of injury, but less distinctly and not continuously.

In case a considerable sac is formed between the vessels, a pulsating tumor may be produced similar to ordinary circumscribed aneurism. The veins, also, may pulsate for a considerable distance from the seat of the injury. Interference with the circulation produces swelling of the limb and disturbances of its nutrition, sometimes a higher temperature, and sometimes degenerative changes in the skin. There may be also subjective sensations, such as pain along the course of the nerves, disturbances in sensation of the skin, and sometimes muscular spasms and weakness. The veins communicating with the artery will be increased in size in varying degrees, according to the relative size of the orifice in the artery and the size of the vein into which it empties. If the orifice in the artery be small and if the vein be large, but slight changes may be observed. If, on the other hand, the orifice in the artery is of considerable size and the vein not large, great distention and enlargement of all the veins of the region may take place.

INFLAMMATION OF THE BLOOD-VESSELS

Acute Inflammation of the Arteries.—Acute inflammation of the arteries occurs chiefly as the result of the lodgment of an infected embolus in the course of pyemia. The symptoms and signs are those of pyemic abscess, already described. Suppuration of the interior of an aneurismal sac is spoken of under the head of aneurism. Suppurative arteritis may also occur from direct infection of the arterial wall itself, as in a suppurating wound. Necrotic inflammation of the vessel wall may occur, with rupture and serious bleeding; the secondary hemorrhage which followed amputations and other operations in preantiseptic days was of this description; it is now rarely seen.

Chronic Inflammation of the Arteries.—Chronic inflammation of the arteries is of two kinds:

(1) Atheromatous Degeneration.—The so-called *atheromatous degeneration* occurring in middle or later life, is attended by thickening and rigidity of the arterial coats, with the deposition of lime salts in the wall of the artery, fatty degeneration, and sometimes loss of intima. Thrombi may form in such situations, and portions of these being washed away may cause embolism. In small arteries the caliber of the artery may be diminished, or even occluded (see Gangrene). General arterial atheroma and sclerosis are often associated with cardiac and renal disease, and the condition adds some small danger to the administration of anesthetics and to surgical operations.

(2) Syphilitic Inflammation of the Arteries.—One of the common lesions following syphilis affects groups of smaller vessels, notably the arteries of the brain, and causes sometimes obliteration of their caliber—*syphilitic obliterating endarteritis.* Sudden interference with the nutrition of the brain, causing attacks resembling apoplexy, or more gradual interference, causing progressive cerebral symptoms, headache, limited palsies, etc., are usually due to syphilis when they occur in persons under forty-five years of age.

Diseases of Veins—Acute Phlebitis.—Acute infectious inflammation of veins occurs as the result of infected wounds of the vein itself or of the neighboring tissues. In the course of pyemia, osteomyelitis, erysipelas, suppurative inflammation of the middle ear, as an extension from an infected ulcer, etc. Antecedent to or in consequence of the infection the blood in the vein coagulates, forming a thrombus. Such thrombi often begin upon one of the valves of the vein. Purulent softening of thrombi and their entrance into the general circulation causes pyemia. Acute purulent inflammation and thrombosis of veins usually forms but a part of the symptom-complex of severe septic diseases. If the vein is superficial and of an extremity, in addition to the general septic symptoms, the vein will feel like a hard, tender cord. A periphlebitis is usually present, and some induration of the subcutaneous tissues. The course of the vein may be marked upon the skin by a blood-red, tender streak. If the deep veins are infected and thrombosed, the superficial veins will be dilated. If the vein is large, like the femoral vein, and constitutes the principal vein of the extremity, swelling and edema of the limb will be marked. Abscesses may occur along the course of the vein, and give rise to characteristic signs and symptoms.

Periphlebitis and phlebitis of a less severe type is a common complication of varicose veins of the leg with varicose ulcer. It may also follow superficial infected wounds. The process is mostly confined to the outer coats of the vein and the surrounding connective tissues, and affects one or more superficial veins. Thrombosis of the vein may or may not occur. The symptoms are pain in the limb, a red, broad band on the skin in the course of the veins, and the presence of a hard cord beneath it. Abscess may occur in the course of the vein, or thrombosis of the vein with organization of the thrombus; the vein then

remains impervious as a subcutaneous cord. Deposition of lime salts may take place in the thrombus and form the so-called *vein stones* palpable in the course of the vein beneath the skin.

Thrombosis.—Thrombosis of veins may occur not only as the result of purely septic conditions, but also from chronic disease of the vessel wall, or be due to traumatism, rheumatism, syphilis, the acute infectious fevers, any cause which diminishes the rapidity of the circulation. Thrombi may form in either arteries or veins, and may partly or entirely fill the lumen of the vessels. They may be absorbed or, if infected, undergo purulent softening, or become organized, or cause obliteration of the vessel. Infected thrombi produce, as already stated, localized abscesses and obliteration of the vein, or pyemia. Thrombosis of arteries is less common than is the case with veins.

Symptoms.—The symptoms of thrombosis vary much, according to whether or not the thrombi are infectious, and to the situation and character of the vessel in which they form. The sudden formation of a thrombus which occludes a large artery, such as the main artery of an extremity, are sudden, violent pain in the limb, frequently complete loss of muscular power. These symptoms may be followed by gradual or partial recovery, or according to whether collateral circulation is established or not, occasionally by gangrene of the extremity. This condition is, however, a rare one unless the accompanying veins are thrombosed at the same time, or unless the lumen of all the arteries of the extremity has been previously narrowed by antecedent disease of the vessel walls. I saw thrombosis of the left common iliac artery in a syphilitic, alcoholic young man cause gangrene of the entire lower extremity and death. The larger arteries of the extremity were everywhere filled with thrombi at the time the limb was amputated.

Embolism.—An embolus—from the Greek word meaning a plug—is usually derived from a thrombus, infected or noninfected, or from fibrinous vegetations forming on the valves of the heart, from globules of fat derived from a recent fracture, from air which has entered a wounded vein at the root of the neck, from a portion of fibrin derived from the sac of an aneurism, or a portion of a malignant tumor which has invaded the wall of a vein. The embolus derived from any of these sources enters the venous or arterial blood-current, and is carried by that current until it lodges in a vessel so small that it cannot pass. Emboli derived from veins enter the right side of the heart or the liver and lodge in the lungs, usually, or in the liver if they are formed in the portal circulation. Those which are derived from the left side of the heart, or have passed through the lungs and enter that side of the heart, finally lodge in some artery of the body so small that they cannot further pass.

If the emboli are infectious, they produce metastatic abscesses or specific infiltrations (tuberculosis), etc., as already indicated. If they are noninfectious, they produce disturbances of circulation and of nutrition and function which vary in character and intensity with the size and situation of the vessel plugged. In the brain they produce paralyses or death. If they lodge in an

arterial trunk of one of the extremities, they produce disturbances of circulation and nutrition in the limb which vary in intensity according to the size of the artery plugged and the general nutrition of the individual. If the main artery of a limb is occluded by an embolus, partial gangrene of the extremity is an occasional result. If the general circulation of the individual is in good order, gangrene will rarely occur with proper care and treatment.

Signs and Symptoms.—The signs and symptoms of the lodgment of an embolus in a large artery of an extremity are sudden violent pain in the parts supplied by the artery, loss or diminution of muscular power. The skin becomes pale and cold; there is a subjective sensation of numbness, sometimes hyperesthesia followed by loss of sensibility if gangrene is threatened. The subsequent history is that of gangrene in unfavorable cases, and of a gradual return to normal if the collateral circulation is established.

Varicose Veins.—Veins which become dilated or tortuous, with or without a notable thickening of their walls, are known as varicose veins. The condition may be due to a variety of causes; to mechanical interference with the flow of blood through the veins, as, for example, in cirrhosis of the liver, the portal circulation being interfered with, the blood cannot any longer freely traverse the liver and must seek other channels; under such circumstances the veins of the anterior abdominal wall become enlarged and varicose. The pressure of a tumor of the kidney upon the spermatic veins may cause their original branches to become varicose.

In certain situations a very long column of blood must be raised against gravity in its return to the heart; this is notably true of the superficial veins of the lower extremity, and in persons whose bodies are not very well nourished, or whose tissues are flabby and who are obliged to be much upon their feet, a varicose condition of the superficial veins of the leg is a frequent occurrence. The disease is of slow development, and does not usually give rise to very marked symptoms until middle life, although it is sometimes observed in young adults, apparently as the result of a congenital weakness of structure or of incompetence of the valves of the veins of the lower extremity. The disease is much more common in women than men, probably as the result of venous obstruction during pregnancy.

Signs and Symptoms of Varicose Veins of the Leg.—The veins form tortuous, rounded, columnar eminences upon the front and sides of the leg extending from the ankle up to the knee, and in some cases along the inner and anterior aspect of the thigh as far as the saphenous opening. In thin-skinned individuals they may have a blue color. Fusiform or bulbous enlargements of the veins may sometimes be observed, and indicate the position of valves. The veins grow smaller or disappear when the patient lies down. Upon palpation the veins are soft and compressible, and insensitive unless inflamed. They vary much in size; if the smaller veins are affected they will be quite small, but very numerous. In ordinary cases there will be four or five or more of the larger veins and their communicating branches involved; these may

be as large as a lead pencil, or even as a good-sized finger. If the saphenous vein is varicose at the saphenous opening, it may simulate a femoral hernia. Both are apt to disappear when the patient lies down. Pressure upon a femoral hernia at the saphenous opening will prevent its descent; pressure at the same point will only make varicose veins appear larger.

Fig. 129.—Varicose Veins of the Leg.

The *subjective symptoms* of varicose veins are slight at first; later there will be a sense of fullness or dull pain in the limb. After the varicose veins have existed for some time, the nutrition of the skin of the limb suffers, and a chronic eczema of the leg, with acute exacerbations, is developed. As the result of scratching or of slight traumatisms an ulcer forms frequently at the junction of the middle with the lower third of the leg. These ulcers are apt to become chronic. The frequent attacks of eczema produce pigmentation of the skin, and the skin becomes indurated and thickened from the chronic inflammation. The ulcers slowly increase in size, and may even entirely encircle the extremity. In neglected cases attacks of acute infection of the ulcer occur from time to time, leading to necrotic inflammation of the base of the ulcer, sometimes to gangrene with putrid decomposition of the raw surface. Such gangrene is, however, limited to the base of the ulcer. Involvement of the wall of one of the dilated veins in the ulceration, or the accidental wounding of such a vein, leads to serious and even fatal hemorrhage if untreated.

Accompanying the attack of infection there are frequently phlebitis and periphlebitis of the enlarged veins, with the signs and symptoms already described under Phlebitis. The inflammation of the veins may cause their obliteration or the formation of abscesses, but is rarely attended with more serious results. In comparatively rare cases epithelioma may develop upon the base of one of these chronic ulcers of the leg.

CHAPTER XI

THE X-RAYS IN SURGICAL DIAGNOSIS

The use of the X-rays in surgical diagnosis may be properly considered under several heads:

I. The X-ray apparatus. II. Technique: (*a*) The fluoroscope; (*b*) the making of X-ray pictures and the development of the photographic plate; (*c*) stereoscopic radiography. III. Diagnostic value of the X-rays in injuries and diseases: (*a*) Fractures, dislocations, and deformities of bone; (*b*) in diseases of bones; (*c*) in the detection and localization of foreign bodies; (*d*) in the recognition of tumors and diseases of the soft parts; (*e*) in the detection of pathological concretions (stone in the kidney, ureter, the urinary bladder) and the detection of biliary calculi; (*f*) the injuries produced by the diagnostic use of the X-rays upon patients and upon X-ray operators.

I. THE X-RAY APPARATUS

Current

With the static machine no outside source of electricity is required, but the street current is a very convenient source of power. For induction coils the street current of 110 volts is the most convenient and efficient source. Batteries, either primary or storage, may be used, but are generally less efficient. To operate large coils efficiently the original cost and expense of maintenance of such batteries would be very great. The alternating currents may be used with the Wehnelt electrolytic interrupter on an ordinary coil; it is said, however, to be more destructive to the interrupter than is the direct current. The several forms of apparatus designed to be used with the alternating current of high voltage are said to be less satisfactory than ordinary induction coils.

Apparatus

In order to excite X-ray tubes for the production of X-rays we may use a static electric machine or an induction coil.

Static Machines.—Static electric machines are believed by certain operators to possess practical advantages over induction coils. Formerly it was believed that X-ray burns were less likely to be produced by tubes excited by the static

machine; recent experience, however, has shown that this belief was not well founded; some of the most serious burns have been caused by static machines.

Those who prefer static machines allege: (1) That the discharge contains a smaller total of energy; hence there is less heating effect upon the electrodes of the tube, and that, in consequence, the electrical resistance of the tube, or its vacuum, as it is sometimes called, is maintained at a constant quantity during the passage of the current with less difficulty, and the tubes last longer; these statements are no doubt true. (2) There is greater steadiness in the production of the rays, and consequently the image thrown upon the fluorescent screen is clearer and sharper; this is in general correct. (3) Without practical experience with static machines, I should suppose that the necessary time of exposure for the production of radiographs might be more constant for a given density of object to be penetrated than is the case with tubes excited by means of a coil. (4) The machine can be operated without any extraneous source of electricity.

The disadvantages of static machines are: (1) The greater original cost of the apparatus, the necessarily greater size and weight and absence of portability. (2) Uncertainty of action in damp weather unless special precautions are used which sometimes involve a delay of several hours. (3) On account of insufficient energy, except in cases of the very largest static machines, there appears to be inability to produce good pictures of the hip-joint, pelvis, and spine of large adults except after rather long exposures.

Induction Coils.—The advantages of induction coils over static machines are: (1) They are less expensive. (2) They may be made of small size and great efficiency. (3) They may be made portable. (4) They are not affected by atmospheric conditions. (5) They may be made to produce a larger amount of energy than can be used with any tube hitherto constructed, and hence shorter exposures are sufficient. (6) The densest structures may be penetrated in a reasonable time with satisfactory results.

A coil of large size, or at least one giving a very heavy secondary discharge —what is commonly spoken of as a thick blue spark—and a coil of the best obtainable construction is required for satisfactory work. Good radiographs are hard enough to obtain with any apparatus; with an inferior one the difficulties are greatly increased. The more powerful the coil and the heavier its discharge the greater the quantity of electrical energy which may be made to pass through an X-ray tube in a given time, and the greater the photographic effect—other things being equal—of the rays produced by such a tube, hence the shorter the exposure necessary to produce a good negative. Moreover, a tube giving off photographically powerful rays need not be placed very near the patient's skin in order to penetrate the thicker portions of the body; the distortion in the negative is thereby diminished, and X-ray burns are less apt to occur. At the present time there are upon the market in America coils of a number of manufacturers of very perfect construction. Recent improvements make it possible to construct comparatively small and light coils of great efficiency; and

while coils capable of producing a spark in air eighteen inches in length are very commonly used, yet it is probable that a coil giving a thick ribbonlike discharge ten or twelve inches long answers every practical requirement equally well.

Interrupters.—Quite as important as the coil is the character of the device used to cause interruptions in the primary circuit. The more complete and sudden these interruptions can be made the better, and, within certain limits, the greater the rapidity of these interruptions the heavier the discharge from the secondary coil in a given time and the shorter time necessary to take an X-ray picture through a mass of tissue of a given density. The number of devices which have been used for interrupting the primary current is large; they are nearly all so expensive as to increase considerably the cost of an X-ray outfit. Some of them are very efficient, some are less so, and many of them require a good deal of attention to keep them in order. That mechanical interrupter which interrupts the primary current by means of a vibrating steel spring alternately attracted to and released from the core of the main coil, or of a smaller coil, placed in the primary circuit is simple, fairly durable, rather noisy, and only efficient when used with coils of moderate size and for the production of a secondary discharge of only moderate quantity. It is in my experience less efficient than some of the other forms when a heavy secondary discharge is desired. Nearly all the mechanical interrupters require a condenser in the primary circuit. The mechanical break-wheel interrupter is efficient but very noisy. The mercury-jet interrupter is clean, not noisy, but scarcely permits the production of as heavy a secondary discharge as is sometimes desirable.

The electrolytic interrupter of Wehnelt, or some modification of it, is in very general use at the present time, and although certain troubles and disadvantages attend its use, these are more than compensated for by the advantages about to be described. It is now made in many forms. It may be constructed in a simple form by any one possessing the slightest mechanical aptitude, at a cost of five dollars at the most. No condenser is required, and while the apparatus is best suited to the use of the direct current, the alternating current may be used with some slight difficulty, since the device permits the passage of a current in only one direction. When used with a coil of suitable construction, the efficiency of the apparatus is very greatly increased; for example, when using this interrupter one may take a good picture of the adult elbow in a second, whereas with a very good mechanical interrupter, on the same coil and with a similar tube, several minutes may be required to produce the same result. Inasmuch as this chapter may be read by some one anxious to try this device, but unfamiliar with its construction and unwilling to go to the expense of its purchase in a finished form, a short description of a simple form of it is here given, together with the method of its use.

Principles and Construction of the Wehnelt Interrupter.—The action depends upon the following facts: If a plate of lead and a piece of platinum wire, the latter insulated except for a small portion at one end, are immersed in a vessel containing dilute sulphuric acid of a specific gravity of 20° 25°

Beaumé, and a current of electricity is passed through the acid by attaching the positive pole of the source of current to the platinum and the negative to the lead, and if the tension of the current is considerable (best 80 volts or more), electrolysis of the water takes place with the disengagement of gas at either pole. If the platinum point projecting into the acid is of the proper size the bubbles of gas forming about it cause a very sudden break in the current, and as each bubble of gas leaves the platinum or is destroyed, the current is reëstablished, a new bubble is formed, and the current is again broken. This phenomenon repeats itself with a rapidity which varies directly as the strength of the current and inversely as the area of platinum exposed in the acid. The interruptions in the primary current occur many thousands of times a minute. With a small area of platinum and a powerful current they may be made to occur some hundreds of times a second. These interruptions, so sudden, so complete, so rapid, greatly increase the energy of the secondary discharge, and excite in X-ray tubes rays of great power. A simple form of the apparatus may be constructed as follows: Any one of the ordinary types of glass battery jars, best of a capacity of several quarts and of a depth of eight inches or more, may be used as a receptacle for the acid. Upon one side of the jar there is suspended in the acid a plate of lead having a superficial area of eight inches or more, in electrical contact with a binding post, for attaching to the negative pole. The arrangement of the platinum electrode may be as follows: A piece of copper wire, a foot or more in length, size 14, is annealed by heating in the flame of a Bunsen burner for a distance of an inch and a half on one end. The annealed portion is hammered flat into a tape. After hammering, it is again annealed. A piece of platinum wire (best containing a little iridium), an inch or more in length, size No. 16 to 14, is tightly wound with the tapelike end of the copper wire for a distance of half an inch from one end. A piece of ordinary lead-glass tubing, one third of an inch outside diameter, serves fairly well as an insulator. The platinum and copper wire are inserted into a piece of this tubing, about a foot in length, until the point of the platinum is just even with the orifice of the farther end of the tube. It is convenient to thread the copper wire upon two little disks of cork, with notches cut out from one side of each, and of such size as will pass easily into the caliber of the glass tube. The platinum wire can thus be properly centered in the orifice at the end of the tube. The edge of glass tube surrounding the platinum point is then neatly fused in the blowpipe flame until the tube is closed at that end, leaving from 2 to 4 mm. of platinum point projecting from the end of the tube, which should have a shape not unlike the apex of a steel-jacketed military rifle bullet. If lead-glass tubing is used, and the fusing is carefully done, and the glass is allowed to cool slowly, the insulation will last for a number of weeks, daily use, and ten minutes' work serves for its replacement in case of breakage, at the cost of a penny or two. Should an adjustable electrode be desired, one of the small lava tips with a single round perforation, such as are used in certain gas engines, and which can be pur-

chased for thirty-six cents a dozen, may be fused into the end of a glass tube, and the platinum electrode, which must accurately fit the hole in the lava tip, may be made to project to any desired extent through this orifice. To prevent the acid from running up into the interior of the glass tube, a little melted vaselin may be poured into the top of the tube and allowed to fill the space between the platinum wire and the lava. The hole in the lava tip may be enlarged to any desired size by means of a fine rat-tail file dipped in turpentine. A more durable and ornate apparatus may be made out of a piece of hard-rubber tubing, into the bore of which a brass rod is accurately fitted. Upon one end of the brass rod is brazed a piece of platinum wire, size 14 or 16, and upon the other there is a binding post, and beneath it a movable screw nut with a milled head. A screw thread is cut in the interior of the lower end of the rubber tube, and into it is screwed a lava tip, perforated to admit tightly the platinum wire. The platinum electrode thus becomes adjustable. This arrangement is a device of Dr. R. H. Cunningham, of this city. The lava tips are made of any desired size or shape by D. M. Stuard, of Chattanooga, Tenn. It is desirable that the lava tips should be more or less conical in shape, at the point which projects into the acid, and through which the platinum wire protrudes; if flattened, bubbles of gas will occasionally accumulate about the platinum point, and the interrupter will cease to operate.

The containing vessel should be of considerable size; otherwise the acid will become hot, and the interruptions will not take place. With a jar containing about 1,500 c.c. of acid, no heating sufficient to interfere with the running of the apparatus has occurred in my experience after half an hour of continuous use. If it is desired to use the interrupter continuously for some time, a second jar of acid may be kept in readiness, and the electrodes may be transferred to it, when the acid in the first jar becomes hot.

If the error is made of attaching the negative pole to the platinum electrode and the positive to the lead, the platinum wire will be fused.

The positive and the negative poles may easily be distinguished by holding them separated in a glass of water. The pole from which the greater quantity of gas escapes is the negative pole. The interrupter, the rheostat, and the switch for turning off and on the current are arranged in series in the primary circuit of the coil. One of the greatest advantages of the apparatus is the ease with which the amount of energy of the secondary discharge can be regulated to suit the capacity of any X-ray tube. With a small amount of platinum protruding into the acid the interruptions occur very rapidly; but the total energy is small, and if considerable resistance is thrown into the circuit by means of a rheostat, a lightly built tube may be made to do its best without undue heating effects. If, on the other hand, the platinum is protruded to a considerable extent and but little resistance is left in the circuit, the interruptions are less rapid; but the amount of energy produced is greater than the heaviest tube can endure for more than a very short time.

It is stated by makers of coils that this interrupter tests the efficiency of

the insulation of the coil itself much more severely than any other. A thoroughly well-made coil is therefore indispensable. As a protection against an accident so serious as a perforation of the insulation of the coil, I am in the habit of setting the parallel spark-gap of my coil at a distance at least several inches less than the maximum separation. I may add that this interrupter requires no care beyond the addition of water and acid now and then, and at long intervals the removal of the brass rod and the injection of a small quantity of vaselin into the caliber of the hard-rubber tube. This affords protection against the ascent of the acid into the interior in case the platinum wire does not fit accurately into the bore of the lava tip.

If the lava tip becomes damaged in time, it may be replaced in a moment at a cost of eight cents. It is well to paint the junction of the lava and hard rubber with a solution of asphalt and chloroform.

The Caldwell Interrupter.—I have also used an electrolytic interrupter made by Wappler Brothers of this city.

The principle of its construction was discovered by Mr. Caldwell, of New York, and the instrument is a modification of the Caldwell interrupter. Its construction is as follows: A glass-battery jar containing dilute sulphuric acid holds two lead electrodes; one of these electrodes is contained within and the other surrounds a porcelain cup. In the wall of the porcelain cup, below the level of the acid, are bored several minute holes, which serve in some sort for the transmission and interruption of the current. The rapidity of the interruptions produced is very great, and varies directly with the quantity of the current. The amount of energy produced in the secondary discharge appears to depend upon the number of holes in the porcelain. The holes may be one sixty-fourth of an inch in diameter. I have not been able with this interrupter to get a sufficiently heavy discharge to operate large tubes to the best advantage. This interrupter has the advantage of being very simple; it requires no care and is almost noiseless.

Since the preceding portion of this chapter was first written, several years ago, a number of modifications of the Wehnelt interrupter have been devised. Porcelain is now very generally used instead of lava, and a long porcelain tube is substituted for the combination of hard rubber and lava. The interrupter has also been combined with a mechanical device whereby, through the action of a small electric motor, the anode is made to plunge rapidly in and out of the acid. It is questionable whether any of the more radical modifications are improvements.

Tubes.—The most recent experiences of those interested in X-rays throughout the world point conclusively to the advantage gained by the use of X-ray tubes which permit the passage through them of a very large amount of electrical energy. It is quite true that with a very rapid series of impulses at high tension much may be accomplished with a current of very small ampèrage; but to obtain satisfactory pictures of the thicker parts of the body in a short time the amount of energy passing through the tube must be considerable,

and to this end tubes of large size and of rather elaborate and expensive construction are required. This necessity depends upon the following facts: The photographic effect of X-rays and their power to penetrate dense structures vary within limits directly with the quantity and intensity of the current, and with the number of interruptions or impulses passing in a given time. The efficiency and character of the rays depend also upon the degree of rarefaction or vacuum within the tube; and, since a higher vacuum in the tube means also a higher resistance to the passage of the electrical current, the equivalent of this resistance measured by the length of a parallel spark-gap in air becomes a valuable index of the character of the rays which are emitted from a tube, the resistance of which, under varying conditions, has been learned by trial. But the degree of rarefaction and resistance of a tube varies as the result of the passage of an electrical current of high potential through it in two ways.

If enough current is passing to render the surface of the platinum anode red hot, it happens with many tubes, though not with all, that the resistance of the tube to the passage of the current, as well as the degree of rarefaction, is suddenly lowered. In this condition the X-rays produced have a lower penetrative power, and if the tube is kept running in this state for a short time it may become temporarily useless for photographic purposes.

If, on the other hand, such a tube is allowed to cool, it will usually be found that its vacuum has been raised to a higher degree than before it was heated. The resistance of the tube to the passage of the current has been increased, and the rays given off from such a tube possess a greater power of penetration. The longer the tube is used, the more marked does this change become, until, in spite of various temporary remedial agents, no current can be made to illuminate it. If the effort is persisted in, the electric sparks may pass around the whole length of the tube, or, what is unfortunately more common, they will perforate the tube, allowing the entrance of air, thus destroying the vacuum, and therefore the usefulness of the tube.

It will thus be seen that any device that enables the operator to reduce the vacuum in a tube which has become "hard," as it is called, greatly prolongs the useful life of the tube.

But, aside from the question of expense involved, the far more important consideration must be noted that with a tube the vacuum of which is constantly changing both during and out of use, and hence also the penetrative power of its rays, the operator using it will have great difficulty in producing uniform results. He will be unable accurately to judge how long an exposure will be necessary to produce good radiographs of objects having the same density upon different occasions. The object of radiography is, in general, to produce shadow pictures which, while showing detailed shadows of the densest structures, such as bones, foreign bodies composed of metal and the like, will also show the shadows of less dense structures, such as calculi in the kidney, gall-bladder, ureter, and elsewhere, and of organs, muscles, tendons, and other soft tissues. In order to make such radiographs, it is necessary to use a tube of

such penetrative power or vacuum as will represent upon a photographic plate comparatively slight differences of density, and, briefly, it may be stated that the majority of radiographers agree that a tube that answers these requirements best is one of comparatively low vacuum, but which will permit the continuous passage through it of a large amount of electrical energy without a still further fall of its vacuum. From what has already been written in explanation, it is easy to understand that a tube that can be run for a long time with a heavy current without much change of vacuum up or down, and one which possesses some device for bringing down the vacuum to any desired extent after it has become too high, must be very valuable and greatly to be desired. I wish to emphasize my remarks in regard to this essential quality in a good tube. The necessity has already been dwelt upon by Dr. C. L. Leonard of Philadelphia, and others; and yet I am led to think that its full significance is not appreciated by everyone who takes radiographs. An ideal X-ray tube would be one permitting the use of a heavy current, a great rapidity of interruption, while maintaining a constant vacuum. The best modern tubes are constructed with a view to obtain these qualities; in some of them one quality has been gained while others are lacking, and, as far as I am aware, no tube has been devised which combines them all in a satisfactory degree. There are several types of tubes which fulfill the conditions fairly well. Among them are the Queen self-adjusting tube, the tube of E. Gundelach, of Berlin, and the tube of Dr. E. Grünmach; they are all obtainable in New York.

1. *The Queen Tube.*—The Queen tube depends for the constancy of its vacuum upon a most ingenious device. A small secondary tube is attached to the main tube. The vacuum of the latter is very high. When the current is turned on, the resistance of this vacuum is so great that the electricity is forced to pass through the smaller tube, the resistance of which is less. In so doing a small platinum anticathode is heated, and this heat drives off a small quantity of watery vapor from a hygroscopic salt in communication with the main tube, thus lowering its vacuum and resistance. The current passes through the smaller tube until the resistance of the two circuits is equal, when it passes through the main tube, causing the production of X-rays.

The resistance through the circuit of which the smaller tube forms a part is adjustable by means of a spark-gap, and the extent of this gap is thus a measure of the resistance of the circuit. The main tube having become illuminated, the current ceases to pass through the smaller tube and across the spark gap, the hygroscopic salt cools, reabsorbs the watery vapor from the main tube, increasing the resistance, when the current passes again by the other circuit.

This process is repeated indefinitely, thereby keeping the main tube at a constant vacuum, and furnishing thereby X-rays of the same penetrative power as long as the spark-gap remains the same. The principle, construction, and operation of these tubes are admirable, but as yet they have not been made upon a sufficiently large and heavy model to permit the use of enough energy to make good radiographs of the trunk and hip-joints of large individuals in a

reasonable time. My best radiographs of parts thinner than the hip have been made with these tubes, but they have repeatedly failed in my hands to produce good negatives of the pelvis, spine, and hips of large subjects. The platinum anticathode is not heavy enough to endure the prolonged use of enough energy for the purpose. If the automatic attachment for the regulation of the vacuum could be united with some efficient cooling device, the combination would leave little to be desired. Since the above was written, this advantage has been obtained.

2. *The Tube of E. Gundelach.*—The tube of E. Gundelach, of Berlin, possesses no special device for maintaining a constant vacuum, but operating indirectly toward this end the anticathode is massive, and the heavy piece of metal of which it consists is seated upon a hollow metallic cylinder, about six inches in length. Much of the heat produced upon the surface of the anticathode is thus dissipated, and the tube permits the use of a large amount of energy continuously for several minutes without much fall of vacuum. It suffers, however, after the passage of a heavy current for three or four minutes, and does not recover itself until completely cool, and after continuous use the vacuum rises after cooling to a degree which renders the tube entirely unfit for the production of good pictures.

To overcome this difficulty, the tube is provided with a regenerative apparatus, so called. This consists of a small side tube, into which is fused what appears to be a piece of platinum wire. One end of the wire projects into the interior of the tube, the other into the air. If this wire is heated for some seconds in the flame of an alcohol lamp the vacuum of the tube falls. This heating must be cautiously performed, or the vacuum may be reduced too far. The lowering of the vacuum is said to depend upon the escape of hydrogen gas, which has been occluded in the wire and is driven off by heat. The metal in the interior of the tube is coated with an enamel which is supposed to prevent the purple cloud which forms upon the interior of X-ray tubes after they have been used for some time.

I have used these tubes for radiographs of the more difficult kind with good results, but I have not found the regenerative apparatus easy to control. This tube is now (1909) considered the best obtainable tube.

3. *The Tube of Dr. E. Grünmach.*—The tube of Dr. E. Grünmach has a device intended to prevent the heating of the anticathode and a device for lowering the vacuum when it has reached a high point. The device for preventing the heating effect of the current is very efficient. The anticathode of platinum is supported by a metal cylinder of aluminum. Within this cylinder is another made of lead, closed at the end in contact with the platinum. The other end is in communication with the outside air, and into the aperture is thrust a perforated cork, holding two small metal tubes, which serve to permit the circulation of a current of cold water, which carries off very rapidly the heat generated by the bombardment of the anticathode. The cold water is readily supplied from the house tap through the medium of a small rubber pipe.

Another pipe carries the waste into the sink. The device for lowering the vacuum consists of a small side bulb, containing a salt which gives off water when heated.

By careful heating with a lighted match, the vacuum may be reduced gradually to any desired point.

This cold-water tube, as it may be called, permits the use continuously, without notable change in the quality of the rays given off, of a far larger amount of energy than is the case with any other tube that I have seen.

The photographic effect through the densest structures is also accomplished in a satisfactory way in a short time. When using a large amount of energy for more than three minutes, the anticathode does become heated to a dull-red heat in spite of the cold water, but the vacuum does not appear to fall to a serious extent even when the tube is kept running in this heated condition.

If the current is stopped, the vacuum promptly rises nearly to the original point.

For *heavy* work this tube is, in my opinion, incomparably the best with which I am acquainted.

Since the above was written numerous changes and some improvements have been made in the construction of X-ray tubes; they consist in cooling devices; in devices for keeping the electrical resistance of the tube constant automatically while the tube is in use; and in the construction of tubes capable of enduring a very heavy discharge without material change in the vacuum and of devices intended to prevent the passage of the current through the tube in the wrong direction. A description of these devices may be found in the catalogues of the makers of X-ray apparatus. There are also used multiple spark-gaps in series with one or both of the electrodes of the tube in the secondary circuit, they are very useful aids in rendering the secondary discharge of the coil of a suitable intensity, such that X-rays of the desired penetrative power may be produced at will.

II. TECHNIC

The General Technic of Radiography

The strictest attention to details, from first to last, is necessary in order to produce uniformly good results. The operator must, of course, become thoroughly familiar with every part of the apparatus under varying conditions. This is particularly the case with regard to X-ray tubes, and he who purchases two or three of the best tubes obtainable learns to know for what purposes each one is best suited, and guards them with care from accidental injury, will soon learn to know, from the mere appearance of the tube, while illuminated, what sort of a result is likely to be produced in the way of a picture in a given time. Several important mechanical details must be studied, and, as far as possible, the relation of the tube to the plate and to the part to be pictured should be reduced to some definite system. It will be remembered

that, as far as is known, the X-ray may be assumed to proceed from the center of the platinum anticathode in straight lines in all directions from a point or focus upon its surface. There follows the well-known rule, also applicable to ordinary light rays, that the intensity of the illumination of an object varies inversely as the square of its distance from the source of light. When applied to radiography, this physical fact is important to bear in mind—e. g., if a good radiograph of a given part can be obtained at a distance of, say, twelve inches in one minute, at a distance of twenty-four inches, an exposure of four minutes will be required to produce the same result. Since in practice it is necessary, on account of the varying thickness of different parts of the body, to vary also the distance of the tube from the plate between limits which may reach from twelve to twenty-four inches or more, this difference in time of exposure becomes a very important practical detail. In fact, to determine the proper time of exposure for a given case, in order to produce a negative having certain definite qualities, is the most difficult question which the X-ray operator has to answer. Inasmuch as many of the problems which are to be solved do not admit of answers which can be measured mathematically, the elimination of this single error of the relation between distance and time is a matter of a great deal of consequence. I have prepared a table of comparative times and distances, based upon an exposure of ten seconds at a distance of ten inches, and have calculated the additional time necessary for all distances from ten to twenty-four inches. I find this table a useful aid for reference. In the effort to formulate a general rule for the duration of exposure for the production of radiographs, Donath ("Die Einrichtung zur Erzeugung von Roentgen-Strahlen," Berlin, 1899) has constructed a table upon the following basis: It is assumed that the various parts of the body possess a power of absorbing X-rays, which varies directly as their density, and, if the absorbing power of the middle hand through the metacarpal bones be taken as the unit of measurement of this quality, experiment and calculation give the following values for the absorbing powers or resistance to the passage of the rays of the different parts of the body:

	Resistance
Hand	1.0
Forearm	1.4
Elbow	1.5
Upper arm	1.8
Shoulder-joint	3.0
Collar-bone	2.7
Neck	3.0
Skull	4.5
Thorax	3–4
Sternum	3.8
Foot	1.4
Knee	2.0
Leg	1.8
Thigh	3–5
Hip-joint	5–6
Pelvis	8–10

Donath has also constructed a general formula for the determination of the proper time of exposure in any required case. The formula is based upon the above relative table. The terms are:

a = the distance of the tube from the plate in the radiograph of the hand.

b = the distance of the tube from the plate in the picture which is about to be taken.

x = the proper time of exposure sought.

z = the time of exposure necessary to produce a radiograph of the hand.

w = the resistance of the part of the body which it is proposed to take, compared with the resistance of the hand. (This number is, of course, taken from the table of relative resistances.)

The formula then reads:

$$x = z \times \frac{(b)^2}{(a)} \text{ W}.$$

While I have not made practical use of this formula, I fear that individual variations in the densities of the different parts of the body might sometimes render it inaccurate. It is necessary, of course, in every case to establish the unit—i. e., the time required to take a picture of the hand; but a slender hand is often present in an individual whose abdomen is unusually thick; and a heavily boned limb is not infrequently seen attached to a comparatively thin trunk. It will be found also that a slight change in the term W produces a considerable change in the term x.

In addition to the variation in time for distance, the much more difficult problem remains to be solved of estimating the various degrees of penetrability for limbs of different thickness and for individuals of different ages. The tissues of children are far less dense than those of adults, and require a much shorter time even for a given thickness of tissue. The tissues of women are more pervious to the rays than are those of men, and require a shorter exposure. To estimate the relative values of these different factors requires the judgment born of experience. To lay down even an approximate rule appears to me quite unprofitable, on account of the extremely varied character of the apparatus used, and the variations of the same apparatus under different conditions. With the apparatus which I possess, I use chiefly two tubes for different sets of cases. For all parts of the body thinner than the hip-joint I prefer the Queen self-adjusting tube with an extra heavy platinum anode. This tube permits me to use somewhat less than half the total practicable energy of my coil. This represents a heavy stream of sparks, ten and a half inches long, measured on the parallel spark-gap of my coil and the No. 16 platinum wire of the Wehnelt interrupter, protruded 4 mm. into the acid. To obtain the greatest amount of detail in my pictures of the thinner parts of the body, I use with this tube a vacuum which corresponds to a resistance equivalent to from two and a half to three inches, measured on the spark-gap of the tube. The current used is the 110 volts direct street current, and from four to five

ampères. This gives rather a black picture of the hand in the fluoroscope. The bones appear very dark and the soft parts somewhat lighter—but still not very light. The tube, in this condition, would not be suitable for a fluoroscopic examination of the bones of the leg nor even for the elbow-joint in the well-developed male subject. When using this tube for a radiograph picture of the knee-joint of a well-developed adult, I increase the spark-gap of the tube to three and a half or four inches. This gives a bright, clear picture of the hand in the fluoroscope, and in this condition the tube would be suitable for the fluoroscopic examination of the adult elbow and for a moderately well-developed leg. The necessary times of exposure to produce radiographs with this tube are about five times as great as with the cold-water tubes of Dr. E. Grünmach, about to be described. This cold-water tube is intended to be used on a coil giving a spark length of sixteen inches. The penetrating and photographic power of this tube far exceeds that of any other with which I am acquainted. It can be used with an amount of energy equivalent to a very heavy stream of sparks fourteen inches in length for from three to four minutes continuously, without any serious change of vacuum. If the current is kept up for longer than four minutes the anode becomes heated to a dull-red heat, and the vacuum falls a little, but upon turning off the current the tube recovers itself almost completely in two minutes.

With this tube, using a vacuum representing a resistance equal to from eight to ten inches of spark length upon the parallel spark-gap of the coil, it is possible to take fairly good radiographs of the thicker portions of the extremities in an astonishingly short time. A fair radiograph of the hand and forearm may be taken with an exposure too short to measure—practically instantaneous. The knee-joint may be exposed for ten to fifteen seconds with fair result. I have taken a very good radiograph of the spine, pelvis, and both hip-joints of a well-developed boy, ten years old, in thirty seconds. The ampèrage of the current used under these conditions was between seven and eight ampères. Even shorter exposures than this are said to be sufficient. But in practice I find that pictures showing more detail and slighter differences in density can be produced by a different method—i. e., by reducing the resistance of the tube and its vacuum to a degree equivalent to from three to four inches upon the spark-gap of the coil. When used in this way, the tube gives a fluoroscopic picture of the hand which is clear, but fairly dark. And yet, with the tube in this condition, my best radiographs of the spine and pelvis of adults have been obtained. The exposures necessary to produce strong negatives are as follows:

Adult hand and wrist, distance of tube from plate 13½ inches, time ten seconds.

Adult elbow, distance 16 inches, time thirty seconds.

Foot and leg, 16 inches, time forty-five seconds.

Knee-joint, distance 18 inches to 2 feet, time two to two and a half minutes.

Shoulder-joint, 21 inches to 2 feet, two and a half minutes.

Thorax, distance 2 feet, three minutes.

Adult hip-joint, pelvis, spine, and kidney regions: females, four to six minutes; males, six to eight or even ten minutes; distance, 24 to 26 inches or more.

I do not find, however, that it is possible with this tube to get pictures showing such slight differences of density as with the Queen self-adjusting tube, before described. The farther away the tube is placed from the object to be photographed the less the distortion of the picture. In the case of the thinner parts of the body, this distortion is only slight when the tube is placed, say, fifteen or sixteen inches from the plate; but when a picture is taken of the hip-joints, including the pelvis of an adult, and the tube is placed in the middle line of the body, unless the distance of the tube from the plate is more than two feet the distortion is great. The practical lessons to be drawn are that it is advantageous to place the tube as far away from the body as is consistent with a reasonable time of exposure, and in all cases involving an exposure or exposures in the aggregate of five minutes or more to lessen the risk of dermatitis by anointing the patient's skin abundantly with some greasy preparation—lanolin, for example—and by placing between the tube and the patient a grounded screen, consisting of thin cardboard or wood coated with gold foil, or with a thin sheet of aluminium. Whether these measures are an actual protection against burns or not, I am unable to say, but it is probable that they do serve to lessen the likelihood of a subsequent X-ray burn, to some degree at least. When using powerful tubes, with a current of great frequency of interruption, high intensity, and considerable ampèrage, the possibility of producing X-ray burns when taking pictures involving several minutes of exposure should never be lost sight of. The danger is a very real one.

If the operator will keep an accurate record of all the conditions under which each X-ray picture has been taken, he will gradually accumulate a very valuable series of data. Such a record should include the part of the body, the age of the patient, the quality of his tissue—whether fat or lean, flabby or firm, whether large-boned or delicately built—the distance of the tube from the plate, the particular tube used, the resistance of the tube during the time of exposure measured on the spark-gap of the coil, the fluoroscopic picture of the operator's hand during the time when the picture is taken, the position of the rheostat lever or, better, the ampèrage of the primary current, the kind of plate used, the kind and strength of the developer, and the general character of the negative.

Any examining table of firm construction answers fairly well for taking X-ray pictures. A special table is, however, desirable for one who wishes to take up X-ray work seriously; there are many such tables in the market. A table which I had constructed answers the purpose well, and a description of it will be found under Stereoscopic Radiography.

It is convenient to lead the wires from the coil to the tube over a light stand or framework of wood, which may be elevated to a position several feet

above the patient's body. In this way accidental shocks are prevented, and the patient is less likely to disarrange the apparatus during clumsy efforts to get on or off the table. The operator is also enabled to walk all around the table underneath the wires, in order to make such adjustments as are necessary. The body of the patient should be placed upon the table in such a position that the part which it is desired to show upon the plate with the greatest clearness lies vertically beneath the center of the anticathode. For the determination of this relation a plumb line is useful. The patient must be made comfortable by means of pillows and blankets, so that no part of the body is in a condition of muscular tension.

That surface of the limb or trunk nearest to which the lesion is supposed to lie is placed next to the plate.

Some ingenuity in arranging the patient is required at times.

In determining the question of the distance of the tube from the plate, it is a good rule to follow not to put the anticathode nearer than twelve inches from the skin, and for long exposures a distance several inches greater should be chosen.

The time of exposure for the given case will depend, as has already been remarked, upon a number of different factors. A high vacuum tube admits of a short exposure, but the negative produced will show but little detail. A low vacuum tube, even with the same current, will require a longer time, but will produce a negative showing far more detail, and will exhibit much slighter differences of density. Thus, if the question to be answered is merely what is the extent of deformity in a case of fracture, the diagnosis of fracture being evident by ordinary means of examination, or if it is to be determined whether or not a metallic foreign body is present, a high vacuum tube with a short exposure answers well. If, however, the question relates to the presence of a calculus, renal or other, to disease of bone, or to pathological changes in the blood-vessels, or if, in the case of a tumor, it is supposed that the mass consists partly of bone and partly of softer structures, or in any case in which it is desired to show the greatest possible differentiation of density, a low vacuum tube should be used of just sufficient penetration to furnish a strong negative after a reasonably long exposure. I have already given the results of my own experience, but the reader will remember that the time of exposure varies much with different forms of apparatus.

And a certain amount of experimental work is necessary to determine the efficiency of any particular set of apparatus. The more powerful the coil the larger the energy of the secondary discharge, and the greater the capacity of the tube to endure a heavy current for a long time the shorter the exposure.

The most modern coils and tubes permit the operator to use exposures quite a little shorter than those I have designated in this chapter; the thinner portions of the body may be taken with exposures almost instantaneous—a second or two at most—and satisfactory pictures of the hip-joint and spine in adults

of ordinary size may be obtained in less than a minute. These short exposures are very desirable; first, because the danger of producing an X-ray burn is reduced to a minimum; second, because the patients are much less likely to move during the exposure, and thus ruin the picture; and third, because the patient is not obliged to remain long in a constrained position.

Before turning on the current the operator should have informed himself of a number of details in regard to his apparatus. He should know just how much energy the particular tube he is using will stand, and for how long; and this once determined, he should use the same amount of current and the same rapidity of interruption with that tube for every case or his results will not be uniform. He should also know by trial whether the vacuum of the tube is suitable for the case in hand. If it is already too low, the tube will not answer for that case; if too high, he must reduce it to the proper point, to be determined by the parallel spark-gap and the fluoroscope.

To know what degree of vacuum in a given tube is best suited for a radiograph of a given case requires, above all things, experience. But a general idea may be obtained by the appearance of the bones of the hand in the fluoroscope. If the shadow of the hand is so dark that the bones cannot be seen distinct from the flesh, the tube is only suitable for the thinner parts of the extremities, and for them only in case the tube in question permits the use of a large amount of energy. The relation between the penetration, as shown by examining the bones of the hand, and the power of the tube to produce a picture of a part of a given thickness is not absolute, but relative. For example, a high vacuum tube, giving a good fluoroscopic picture of the thorax, but which permits the use of a small amount of energy, may entirely fail to produce a satisfactory picture of even a part as thick as the adult knee-joint in any reasonable time, whereas, a tube of very low vacuum indeed, through which a heavy current may be passed continuously for several minutes, will often produce a good negative in a much shorter time. A tube of medium vacuum, such that the bones of the hand when viewed through the fluoroscope show clear and distinct and sharply marked while the flesh is much lighter, is, upon the average, best for general work.

A very high vacuum tube is of but little use for taking pictures. The operator will in general be obliged to establish his own standard, it being true of radiography, as of most other practical arts, that an ounce of experience is worth several pounds of precept.

In general, one is much more likely to expose for too short a time rather than for too long; and whereas the negative produced by an overexposure is still capable, with careful development, of furnishing a good picture, an underexposed plate is hopeless, and no amount of development will bring out that which is not there.

Distortion.—Owing to the fact that the X-rays originate from a point or focus upon the surface of the anticathode, and proceed in straight lines in all directions from its surface, and since no one has as yet been able to refract the

X-rays by means of prisms or lenses for practical use, it admits of a simple demonstration that the projections of any two points in the same vertical line placed between the surface of the anticathode and the photographic plate, but removed from the vertical dropped from the anticathode on the plate, will fall upon the plate at two points separated by a horizontal distance the extent of which will depend upon the distance of the anticathode from the plate, the distance of the two points one from the other vertically, and upon certain other spatial relations unnecessary to elaborate.

In other words, a figure made up of many points situated at various levels will be projected upon the plate as a distorted image, and apparent deformities will be exhibited in the picture which do not exist. This distortion is more marked the nearer the tube is to the plate, the thicker the object, and the farther it lies from the vertical. In the case of the thinner parts of the body the distortion is slight at ordinary distances, but in radiographs of the hip-joint, for instance, at similar distances it becomes extreme, and may render the negative quite worthless for diagnostic purposes. Distortion may be avoided by placing the tube as far away from the plate as is consistent with a reasonable time of exposure. To one acquainted with the relation of the tube to the plate in any given case and accustomed to inspection of X-ray pictures, moderate degrees of distortion may be discounted; but, inasmuch as the medico-legal relations of radiographs are important in certain cases, it behooves us to make a careful adjustment of the tube and the part, and to keep an accurate record of the data.

Attempts on my part to look at distorted pictures through lenses in order to correct the distortion have not as yet met with success.

For obtaining good pictures not a little depends upon the arrangement of the part of the body to be photographed and upon absolute immobility of the part during the exposure; this latter may be obtained for many parts of the body by means of the straps attached to the table, as described; one or more of the straps may be passed across the limb or any other part, and fastened quite tightly.

The Compression Diaphragm.—For the purpose of keeping the patient quiet, of rendering the thickness of tissue to be penetrated as small as possible, and for the further purpose of preventing a blurred image through the setting up of secondary foci of X-rays in the tissues themselves, and by the secondary rays given off from the general surface of the tube, a special and somewhat complicated, expensive and cumbersome apparatus has been devised in Germany by Dr. H. Albers-Schönberg. The apparatus consists essentially of a cylinder of metal about three inches in diameter and eight inches deep. This cylinder is made to press by the rim of one of its open ends firmly against the part of the body to be pictured, and the X-ray tube is placed at the other end. There are further, diaphragms with openings of various sizes which may be interposed between the tube and the skin of the patient; thus the body is compressed by the cylinder, held immobile, and only a limited area of skin is exposed to the

rays. I am not aware that the apparatus greatly improves the quality of the pictures thus taken, although those who use it believe that shorter exposures and clearer shadows are thus obtainable—notably in pictures of the kidney regions and lumbar spine.

Details of Technic.—The most important fact to remember in taking a picture is that the part you wish distinctly to show should be as close as possible to the photographic plate. Moreover, one should so arrange the part that one bone should not overlie the image of another; of course, this cannot always be accomplished, but the effort in that direction should be made. This caution is less important if stereoscopic pictures are taken. If it is believed that a foreign body is present, the part should be placed so that the portion of tissue supposed to contain the foreign body is near the plate. This is of real importance in cases of deeply placed bullets, either in the head, the trunk, or the limbs; such a body may sometimes be roughly located with the fluoroscope before the picture is taken.

Head.—In taking pictures of the head or face, the side which it is desired to show distinctly should be firmly pressed against the photographic plate, and the relation of the tube to the skull and to the plate should be such as to avoid, as far as may be, the production of a composite image of the paired bones of the skull or face. This is not always easy or even possible to accomplish, but a little practical experience is quite useful toward this end. Much distortion of the image will occur unless the tube is placed from eighteen to twenty-four inches from the plate. For picturing limited areas it is often convenient to use very small plates, which may be directly applied, by sticking plaster or other means, to the skin. If the part does not lend itself well to the use of a plate, flexible films may be used sometimes with advantage; small pieces of such films, done up in black paper and then in rubber tissue, may be used in the interior of the mouth, and thus excellent pictures of the teeth may be obtained.

The Shoulder-joint.—One of the most troublesome parts to take is the shoulder-joint. It is necessary that the head of the humerus should be firmly pressed against the plate. The patient should lie upon his back on the table, the forearm of the affected side should be placed across the chest, with the fingers upon the opposite clavicle. It is well to surround the arm and the body with a few turns of bandage. The patient is then rolled over toward the affected side until the shoulder is firmly pressed against the plate; the position must be maintained by firm cushions or sand bags placed under the opposite shoulder and back. The pelvis may also be rotated in the same direction, and supported by a cushion; a small cushion may be used to support the head. The tube should be placed about fifteen inches above the shoulder.

The Collar-bone.—The patient should lie upon his face; the arms should be permitted to hang down on either side of the table. The side of the face should rest upon the table; no pillow should be used. The plate should be beneath the collar-bone, and the center of the anode of the tube

should be above the middle of the collar-bone and distant eighteen inches or more.

The Cervical Spine.—The cervical spine may be pictured by placing the patient upon his side with the plate, which will usually include a portion of the head, resting firmly against the neck and the side of the face. The plate may sometimes be supported upon a block of wood an inch or more high.

The Thorax.—The patient may lie either upon his chest or upon his back, according to the anatomical situation of the lesion which it is desired to show. In order to avoid distortion the tube should be placed as far away as is consistent with a fairly short exposure. The *elbow* may be most conveniently pictured by seating the patient upon a low chair at the side of the table, and arranging the limb upon the table as may seem best to suit the individual case. The same is true of the forearm and hand.

Spine and Kidney Region.—Pictures intended to show the lower dorsal and lumbar vertebræ and the pelvis are best taken with the patient lying upon his back; the head should be well raised from the table with pillows; the thighs should be flexed upon the pelvis and the knees strongly flexed upon the thighs. Only by maintaining such a position as this is it possible in the average case to overcome the normal lordosis of the lumbar spine and to bring the back into firm contact with the plate. This position is rather tiresome. It may be maintained without effort by passing a long trunk strap across the front of the knees; either end of the strap is attached to the table beyond the patient's head; or the strap may be passed around the head end of the table, drawn tight across the knees, and buckled. The knees are thus firmly supported. The abdominal movements of respiration may be controlled by a folded sheet drawn firmly across the belly. The tube should be placed at least a foot away from the surface of the abdomen, with the anode over the middle line of the body and opposite to that part which it is desired to show most clearly in the picture. When seeking to detect stone in the kidney the anode is placed over the middle line of the body, midway between the umbilicus and the ensiform cartilage. The surface of the anode is directed toward the patient's head, and at an angle of from forty-five to sixty degrees with the horizontal. The use of compression of the abdomen by a metal cylinder and a diaphragm is strongly recommended by many observers, the advantages being: (1) Secondary rays from the walls of the tube and from the tissues are avoided; (2) the thickness of tissue to be penetrated is diminished; (3) haziness of outline from respiratory movements is prevented; (4) the exposures may be shorter. Before taking the picture the bowels and stomach should be thoroughly emptied.

The Hip-joint.—In order to picture the hip-joint the patient should lie flat upon his back, with the thighs extended. The plate is placed beneath the hip and the tube, with its anode directly above the head of the femur, at a distance of twelve inches or more from the skin. In case it is desired to show both hip-joints in any patient larger than a ten-year-old child, it is better to picture each hip-joint separately, for if the tube is placed in the middle line

of the body with the intention of showing both hips upon the same plate, considerable distortion will result which might lead to an error in diagnosis unless the tube were placed so far away as to render an unduly long exposure necessary. The shaft of the femur may be arranged over the plate in such a position as seems best suited to the individual case.

KNEE, LEG, AND FOOT.—The knee-joint is best pictured from the side, in most instances; the patient lies upon the table upon his side, with the limb to be pictured next the table. It is best to strap the limb to the table quite firmly. The knee may be moderately flexed upon the thigh. The anode of the tube should be directly over the plane of the articulation. *The bones of the leg* may be very well shown by a side view in either direction. *The deformity of Pott's fracture* is sometimes best shown by a picture taken from before backward, with the heel resting upon the plate. *The ankle-joint and the bones of the foot* may be arranged in one of a variety of positions used to meet the needs of the particular case.

(*a*) THE FLUOROSCOPE

In surgical work the fluoroscope furnishes far less valuable diagnostic aid than do radiographs. In the medical diagnosis of the heart and lungs mere broad differences in the density of shadows are all that is needed; in surgery, on the other hand, details are necessary in the picture, and these the fluoroscope fails to reveal. One may entirely fail to recognize a fracture through the fluoroscope, which shows with entire clearness in a radiograph. To recognize through the fluoroscope the finer details of bone structure, foci of disease in bone, and the like, is quite impossible. Metallic foreign bodies embedded in the tissues can often be seen and located with the fluoroscope, but not nearly so well as by a radiograph.

In using the fluoroscope the room should be darkened, and the observer should remain in the darkened room for several minutes. Some form of interrupter should be used which gives a steady illumination of the tube, the Wehnelt interrupter answers the purpose well. A tube should be selected such that the rays are of a proper penetrating quality for the part of the body to be looked at. For the thinner parts of the body a tube of far less penetration is required than if, for example, we desired to examine the head or the adult hip. In order to get the best effect the fluorescent screen should be placed as near the lesion which we wish to see as possible, and the tube should be as near the interposed part of the body as is consistent with safety from electric shocks. The examination need never last long enough to produce a burn. The part should be examined from several different directions, for by this means a fracture or foreign body may be detected which would otherwise escape notice. My own experience in the use of the fluoroscope has been so disappointing and the results so unreliable that I seldom use it except as a rough preliminary means of diagnosis in examining for fractures

or the presence of foreign bodies, or to try to determine if the efforts at reduction of fractures have been successful after the retaining splints have been applied.

(*b*) The Making of X-ray Pictures and the Development of the Photographic Plate

Any quick photographic plate answers well for taking X-ray pictures; personally, I have found that the Cramer X-ray plates are entirely satisfactory. The plates should be purchased in small numbers, so that they may be fresh, and should be put in the containing envelopes shortly before they are to be used. If left for weeks in the envelopes a peculiar change occurs in the film, causing a mottled and imperfect negative. The plates should be kept in a room as far away from the X-ray machine as possible, or, if kept close by, they should be inclosed in a leaden box. Any of the developers now popular answer very well for X-ray pictures, such as pyro, metol, hydrochinon, eichonogen, rodinal, glycin, etc.

Inasmuch as strong contrasts are desirable in X-ray pictures, what is known as a contrast developer is useful. I have found that hydrochinon gives good results, the formula is as follows:

I. Hydrochinon ..... ℥j;
Sodium sulphite ..... ℥vj;
Potassium bromid ..... ʒss.–℥j;
Water ..... ℥lxv.

II. Sodium carbonate ..... ℥vj;
Water ..... ℥lxv.

Equal portions of No. I and No. II are mixed to form the developer.

If there is reason to believe that a plate is overexposed, a diluted developer should be used or more bromid-of-potassium solution may be added. When developing pictures of kidney stones or of the hip-joint and pelvis, it is well to use a weak developer on account of the possible danger of ruining the negatives, which cannot immediately be replaced without risk to the patient. To avoid the danger of fogging an important plate it is well to carry on the development in absolute darkness, only exposing the plate to the red light from time to time momentarily in order to judge how the development proceeds. For the development of hip-joint, spine, and pelvis cases, from ten to fifteen minutes is enough; for thinner parts of the body, from six to ten minutes, according to what is desired to show. If it is desired to show with the greatest clearness the structure of bone and to blot out the soft parts a form of negative very popular for purposes of exhibition, lantern slides, etc., the development should be carried to a point where the bones themselves appear distinctly dark and the soft parts can scarcely be distinguished from the uncovered portion of the plate.

If, on the other hand, the soft parts as well as the bones are to be preserved on the negative, and in all cases when the radiograph is to be viewed in the stereoscope, a more useful and interesting picture will be obtained by stopping the development while the soft parts are still quite a little lighter than their surroundings and the bones are gray but perfectly distinct.

In this description it is assumed that the exposure has been sufficiently long; otherwise, no amount of development will serve to bring out detail, which is simply not there.

A good average negative will be produced by carrying on the development until the plate becomes opaque when held up before the source of red light.

The use of the so-called "acid-hypo" bath, which hardens the gelatin film and prevents the most annoying accident, known as "frilling," is well worth the additional trouble involved in its preparation. In summer it is almost essential.

While those unaccustomed to the examination of X-ray negatives sometimes find it difficult to appreciate what they represent, and it is therefore necessary to prepare prints or positives, yet much of the value of the radiograph is thereby lost unless the printing is in painstaking and skillful hands. I have been unable to get professional photographers to do this work well, and therefore do it myself when I must, but the surgeon rarely has sufficient time to devote to this, and must put it into the hands of another.

Satisfactory prints of plates showing kidney and ureteral stones are especially hard to make. The different portions of the body are inevitably penetrated to different degrees; and, in order that every portion of the plate should be printed to the proper density, it is necessary to use screens of tissue paper when printing by daylight.

The proper arrangement of these screens for a given case must be learned by experience.

(*c*) Stereoscopic Radiography

The advantages of looking at pictures stereoscopically are several. A single X-ray plate shows the shadow of the object pictured projected on one plane, and thus the true relations of points situated in other places are lost. In order, then, to determine the position of a foreign body—a bullet, for example—embedded in a limb, several methods are open to us. We may take two pictures through planes at right angles to one another, and by a series of measurements from fixed points on the surface of the limb we may determine the actual position of the bullet; or we may take two pictures of the object through planes separated from one another by angles less than a right angle, and by observing the differences in size or situation, or both, of the projected shadows of the bullet on the plate, we may by a mathematical calculation, more or less simple, determine the position of the bullet in the body.

The very ingenious localizer of Mr. Mackenzie Davidson is based upon this principle. If, however, we take two pictures of the bullet upon two sepa-

rate plates from two points of view separated by a distance equal to the distance between the visual axes of the two eyes, the points of view being in a plane parallel with the surface upon which the shadows are projected—i. e., the plane of the photographic plate—the distance being in this case about two inches and a half, and then view the two radiographs in a stereoscope, the two images will combine to form a single picture, and the image of the bullet will be seen in its relations to the bones, the surrounding soft parts, and the skin with sufficient clearness to cut down upon it without further calculation other than such as may be furnished by our anatomical knowledge. This quality of stereoscopic radiographs which permits us to see structures at different depths in perspective is of great value, also, in the diagnosis of the deformities following fractures and dislocations, and in the recognition of the gross pathological changes taking place in diseases and tumors of bones.

Whoever has attempted to recognize the exact amount and character of the displacement in a recent case of fracture from a single X-ray picture, or even from two pictures taken from different points of view and looked at separately, must frequently have suffered vexatious disappointment.

On the other hand, stereoscopic pictures of fractures show the relative positions of the displaced fragments in a very satisfactory manner. The exact relations of the bones of a dislocated joint are seen with great clearness. The limits, and often the character, of tumors growing from or attached to the bones may usually be clearly appreciated. The situation of sequestra and of tubercular foci in bone can sometimes be seen in a satisfactory way.

Apparatus for Taking Stereoscopic Pictures.—In order to take stereoscopic X-ray pictures certain mechanical aids are necessary.

First, a device which permits the X-ray tube to be moved a measured distance in a horizontal or vertical plane, so that the two pictures may be taken from separate points of view in the same plane, distant from one another two inches and a half, equivalent nearly to the distance between the pupils of the two eyes. In other words, the principle is the same as is used in taking ordinary stereoscopic photographs by means of lenses. By this means, as in ordinary binocular vision, we get the impression of depth or perspective when viewing a solid object having points in more than one plane. As applied to radiography, we use, of course, no lens; but, after having taken one picture, we displace the tube two inches and a half, the movement being made parallel to the surface of the photographic plate, and make a second exposure. The second device is used to enable us, after taking one picture, to remove the exposed plate and to substitute for it another, which shall occupy exactly the same position as the first did, and that without disturbing the object to be pictured. For holding the X-ray tube above the body of the patient and permitting the movement of the tube through a measured distance, I find the following apparatus convenient:

A heavy cylindrical bar of hard wood, two inches in diameter, is fixed vertically to one side of the table. This bar may be moved vertically a measured

distance, or horizontally from one end of the table to the other, and may, moreover, be rotated on a vertical axis and fixed in any desired position by means of a friction clamp fastened to a traveling block, which slides in horizontal grooves along the side of the table. Two other sliding blocks, one on either side, serve as guides to any predetermined position of the first. From the upper end of this vertical arm there extends a horizontal arm of wood long enough to permit the X-ray tube to be suspended from it by means of a heavy wooden clamp over any point across the width of the table. This horizontal arm is scaled in inches, so that the clamp which carries the tube can be moved along it a measured distance. The clamp, also of wood, hangs vertically downward from the horizontal arm, and at its lower end bears a pair of grooved jaws padded with rubber, so placed that when the horizontal arm is at right angles with the long axis of the table the X-ray tube is very firmly held with the plane of the anticathode at an angle of forty-five degrees with the surface of the table, and with the long axis of the tube parallel with the long axis of the table. The construction of this gallows frame, as it may be called, is of hard wood, and very heavy for the sake of rigidity. Metal should be avoided as far as possible in its construction. The vertical arm is so graduated in inches that the observer may read at a glance the distance from the center of the anticathode of the table to the photographic plate beneath it on the table (see Fig. 130). The rotation of the whole gallows frame upon a vertical axis is very convenient. By means of this device the tube may be accurately adjusted over any desired point of the table. The horizontal arm may then be rotated to a position which permits the patient to get upon the table without risk of injuring the apparatus. After the arrangement of the patient upon the table, the gallows may be rotated to its former position and the exposure made.

The second device necessary permits the removal of the photographic plate from beneath the patient and the substitution of a second photographic plate without moving the patient. For those who desire seriously to interest themselves in practical radiography, the possession of a special table adds greatly to the convenience of the operator. I have found a table constructed upon the following plan convenient: The table is made of hard wood, built heavily for the sake of stability. It is 6 feet long, 19½ inches wide, and 34½ inches high, and is supported upon eight strong wooden legs. The upper surface of the table contains three rectangular openings, one in the center of the table and one at either end. These openings are 17¾ inches long and 14¾ inches wide. This corresponds to the size of fourteen by seventeen X-ray plates in their envelopes. Over the entire top of the table is stretched a sheet of pegamoid with a canvas backing, held under tension by a row of brass-headed tacks around the edge of each opening, and further by a half-round molding nailed to the edge of the table. The solid portions of the upper surface of the table are padded with a sheet of felt, slightly thicker than an X-ray plate included in its envelopes.

Beneath the table, and corresponding accurately in size and situation to the openings above described, are three wooden plate carriers, which slide vertically up and down in suitable guides (see Fig. 130). Each carrier is raised and lowered by means of strong wooden supports beneath the table arranged in the form of a toggle-joint. When the elbow of the joint is straightened, the plate carriers are raised and pressed firmly upward against the pegamoid covering of the table. When bent, the plate carriers descend and permit the introduction or removal of the photographic plates. A suitable space is provided for this purpose at one side of the table.

The position of the plates upon the carriers is accurately fixed by means of wooden kits of different sizes. The lower limbs of the toggle-joints are pivoted beneath the table upon a heavy iron bar, which extends the whole length of the table. The weight of the patient's body overlying the carriers is thus firmly supported. Upon the pegamoid surface of the table the position of the several sizes of plates is clearly marked by shallow grooves in the cloth corresponding to the situation of the plates beneath. The part to be pictured may thus be arranged upon the surface of the table with reference to the underlying plate. Along either border of the table, and below the level of its upper surface, three pairs of metal knobs or buttons are fastened opposite to each opening. To these buttons thin leather straps are affixed at pleasure. They may be buckled across the part to be pictured, thus securing complete immobility during the exposure.

For those who do not possess a special table the following device is inexpensive and fairly satisfactory. Upon a framework of planking, two feet long and as wide as the table which is to be used for taking radiographs, are nailed two little cleats or strips of wood, a quarter of an inch high, running crosswise from one side of the planking to the other, separated by a distance a little greater than the width of the envelope which inclosed that size of photographic plate which is to be used. Across the top, from one strip of wood to the other, is tacked a sheet of stiff fiber paper, as it is called. A shallow wooden drawer or plate carrier is made of such a size and depth that it slides easily in and out between the strips of wood and beneath the fiber cover.

Methods of Taking Stereoscopic Pictures.—The part to be radiographed is placed upon the fiber covering; the plate in its envelope is then put into the wooden drawer, which can be easily inserted beneath the fiber cover. A picture having been taken, the drawer is pulled out, the plate removed, a new plate inserted beneath the part to be pictured, and a second picture taken. It is sometimes necessary, and usually wise, to hold the part to be pictured absolutely quiet by strips of adhesive plaster stuck to the skin of the patient and to the table.

If the tube has been moved horizontally two inches and half after taking the first picture, the two negatives, when developed, constitute stereoscopic pictures, and may be at once viewed in the reflecting stereoscope.

Another method of taking stereoscopic pictures is to have a plate holder

so constructed that one half the contained photographic plate is shielded from the action of the rays by a heavy sheet of metal. After exposing one half the plate, that half is shielded by the metal screen and the other half is brought beneath the patient.

The tube is moved a suitable distance, and a second exposure is made. The two pictures thus lie side by side upon the same plate, and may be copied in a reduced size, and viewed as positives on glass or paper in a refracting stereoscope.

Apparatus for Viewing Stereoscopic Radiographs.—For viewing stereoscopic radiographs two forms of apparatus may be used: *First*, the Wheatstone Reflecting Stereoscope, which permits us to examine X-ray negatives of any size immediately after they have been developed. Manifestly, a great saving of time, for it is possible to examine the plates in a stereoscope within an hour of the time they have been taken, or the negatives may be reduced in size to three and a quarter by four inches, mounted side by side, viewed as positives on glass or on paper in the refracting stereoscope in common use.

The principle of the Wheatsone Reflecting Stereoscope is as follows: Two rectangular plane mirrors are fixed upon a suitable wooden frame, so that two of their edges being in contact, their surfaces stand at an angle of ninety degrees to one another.

If, now, an observer places his eyes on either side of the apex of the angle made by the mirrors, and if stereoscopic pictures of any object be placed one opposite each mirror, the surface of the picture making an angle of forty-five degrees with the planes of the mirrors, the observer will see the reflected image of the right-hand picture with his right eye and the image of the left-hand picture with his left eye. And if the adjustments are suitable, the brain will combine the two images into a single image, which will appear in relief. This principle may be utilized for viewing radiographs in two ways. Prints may be made from stereoscopic X-ray negatives and placed one upon either side of the mirrors. The advantage of this method is that a very simple form of apparatus answers perfectly. Two pieces of plane glass mirror stuck together along one straight edge and placed upon a table at right angles to one another, with the apex of the angle directed toward the observer's eyes, answers as well as anything.

The photographic prints are placed one on either side, supported by a grooved block of wood. Daylight furnishes a satisfactory illumination.

The disadvantages are, the time and trouble necessary for the preparation of the prints, the inability to view the pictures for at least forty-eight hours after they have been taken, and the loss of detail which occurs when printing on paper from X-ray negatives, unless unusual care and skill are used in the process.

Second, the original X-ray negatives may be viewed by transmitted light in the Wheatstone Reflecting Stereoscope. The advantages of this method are that the stereoscopic effect is appreciated in a very satisfactory manner;

that none of the details are lost; that the plates may be viewed in the stereoscope immediately after development, within one hour after the time the pictures are taken, a practical advantage of great consequence in cases of recent fractures and dislocations. And in cases where foreign bodies are to be detected and located, the time and trouble of preparing the prints are saved. The disadvantages are that a somewhat more expensive and complicated apparatus is necessary to produce satisfactory results. The plates must be illuminated by a source of artificial light placed on either side of the plane mirrors. The light must be diffused; hence, it is necessary to interpose in front of each light a screen of ground glass or opal glass. In front of the screen on either side are placed the X-ray negatives. The center of each negative should be nearly opposite the apex of the angle made by the mirrors.

This apparatus may be constructed in a simple form at a cost of less than five dollars. The mirrors, six inches square or thereabouts, may be set in grooves on a block of wood; other grooved blocks of wood may be placed on either side to hold the plates and the pieces of ground glass. Two electric-light bulbs or two oil lamps, one on either side, serve as a source of light. Any ordinary desk or table furnishes a level base for the entire apparatus. The smallest practical experience only is necessary to arrive at a knowledge of the best relative positions of the several portions of the stereoscope. In order to obtain the very best effects, a somewhat costly and elaborate mechanism is desirable. With the apparatus already described, the diffused light of the room, together with reflections and shadows of one sort or another, serve to obscure to some degree the finer shades of different density in the X-ray negatives; and since the proper interpretation of these slight differences is often of great consequence in the diagnosis, any device which serves to preserve these qualities of the negatives as perceived by the eye is a distinct advantage.

I have found that inclosing the whole apparatus in a nearly light-tight box serves this purpose well. A small square aperture is left in front of the box opposite the apex of the angle made by the mirrors through which the observer looks. The Folmer and Schwing Manufacturing Company, of New York, have made for me a stereoscope of this kind. Its construction is as follows:

A heavy framework of wood, five feet in length and one foot wide, serves as a base for the apparatus. The framework bears upon its surface polished wooden tracks, upon which rest wooden blocks bearing tracks at right angles to those beneath. The several parts of the apparatus bear upon these tracks, thus permitting motions in two directions—namely, along the length of the plank and at right angles thereto. The mirrors in the center and the plate holders upon either side are inclosed in a light-tight box of wood and leather.

An orifice four inches and a half square is left in front of the box opposite the apex of the angle made by the mirrors. The plate holders permit the use of plates measuring eleven by fourteen inches and eight by ten inches. In addition to the horizontal movements, the plate holders may be moved vertically up and down by means of a rack and pinion. These movements of the plate

holders in three planes permit any desirable adjustment to be made. The interior of this central portion of the apparatus is painted a dead black. Upon either side opposite to the plate holders is a sheet-iron box lined with opal glass, and containing twelve sixteen-candle power electric light bulbs. These may be illuminated in groups of six. The sides of the boxes toward the plate holders contain a groove for the reception of a sheet of opal glass, ground glass, or colored glass; or, by a combination, the light may be passed through colored glass and ground or opal glass at will. When using the apparatus, the negatives are placed in the frames, the lights are turned on, and the observer places his eyes in front of the window in the center of the mirror box. The images are then seen in the two mirrors with the right and left eyes respectively. By moving the mirrors a little away from or toward the eyes, the two images unite and form a single stereoscopic picture, the stereoscopic effects produced with this apparatus leaving nothing to be desired.

Another method of viewing stereoscopic X-ray pictures is to photograph the two negatives in a reducing camera. The pictures should be reduced to lantern-slide size—viz., three inches and a quarter by four inches—thus two positives on glass are produced. These are then mounted side by side on a plain glass backing, and are viewed most conveniently in a refracting stereoscope inclosed in a bellows. In order to produce the best effects, a piece of ground glass should be inserted between the pictures and the source of light.

The Folmer and Schwing Manufacturing Company have made for me a refracting stereoscope which answers the requirements exceedingly well.

Method of Producing X-ray Pictures.—For the production of X-ray pictures to be viewed in the refracting stereoscope, the methods used for the making of lantern slides answer well. Slow plates should be used, three inches and a quarter by four inches in size, and to get the greatest amount of detail, a small diaphragm and a long exposure, about one hour for ordinarily dense negatives, with skylight reflected from a mirror on a cloudy day and passed through a sheet of ground glass. A developer giving great contrast and slow development, hydrochinon and bromid, for example, is desirable. Direct light from the sky is best; it may be obtained in the city by the use of a large mirror set outside the window at an angle of forty-five degrees with the vertical, the sky light being thus reflected into the room. In order that the two pictures may combine in the stereoscope, they must occupy the same relative position on the two plates. In order to accomplish this I have found the following procedure useful: After the image of the large plate is accurately focused on the ground-glass screen, best by first focusing on some printed matter or the like, and then substituting for it the X-ray negative, measurements in two directions at right angles one to the other are taken from some bony point and line of the reduced image to the edges of the ground-glass screen. These measurements are noted, and the image of the second negative is made to conform precisely to them. The two pictures, when mounted, will be found in the correct position. These reduced stereoscopic positives on glass are very satisfactory,

and appeal strongly to those who are unaccustomed to examine and interpret X-ray negatives.

There is usually one relative position in which stereoscopic pictures show to the best advantage. They are, so to speak, rights and lefts. If the picture taken when the tube was farthest to the right is viewed with the right eye, and the other with the left eye, the stereoscopic image will appear with the dorsal or ventral surface of the limb toward the observer, according as the dorsal or ventral surface was next the photographic plate. If the position of the pictures is reversed, the limb will appear as though looked at from the opposite surface, and usually one of these arrangements is optically more satisfactory than the other. The apparent point of view may also be changed by turning the separate pictures to face the other way without changing their relative positions; but once mounted together side by side in permanent relation, no amount of turning will change the apparent point of view; so that if it is desired to view the pictures from both directions, they must either be kept separate or else two pairs must be mounted in different relative positions.

In taking X-ray pictures for stereoscopic effects, it is desirable that distortion of the image should be avoided as far as may be. A distance of from twenty-six to twenty-eight inches from anticathode to photographic plate is sufficient to prevent undue distortion, unless both hip-joints of an adult are taken on one plate, in which case it is better to remove the tube sill farther away. To formulate any rule for determining the proper time of exposure in a given case is very difficult. The operator must know what his apparatus is capable of doing, and experience is the only guide. The tendency is to underexpose rather than the contrary.

III. THE DIAGNOSTIC VALUE OF THE X-RAYS IN INJURIES AND DISEASES

(*a*) Fractures, Dislocations, and Deformities of Bone

The X-ray Diagnosis of Fractures.—The diagnostic value of the X-rays in fractures can hardly be overestimated. With perfect technic and suitable apparatus it is scarcely possible for a fracture of any of the bones of the extremities or of the shoulder girdle to escape detection. Fractures of the skull and of the bones of the face are less easily detected by this means. Fractures of the neck of the femur can be detected in nearly all cases. Fractures of the pelvis may or may not be detected, according to their situation, and fractures of the cervical spine are usually detected with ease. Fractures of the remainder of the spine can be detected under favorable conditions. Fractures of the ribs can usually be detected without much difficulty.

Certain Limitations.—The limitations of the X-ray in detecting fractures depend upon the impossibility of bringing certain bones or parts of bones in close proximity to the photographic plate. The shadows of such parts as the

bones of the extremities, except the upper portion of the femur, may be made so clear and distinct that no fracture can exist and fail to show in the negative. Fractures with much displacement or comminution will, of course, show even in a very inferior negative; but incomplete fractures, impacted fractures, and fractures with little or no displacement, or—assuming that a single picture only has been taken—fractures in which the displacement is in only one plane, and that in the plane of the rays as they fall upon the plate, may fail to show unless the picture be very good indeed, or unless stereoscopic negatives are made and viewed in a stereoscope. In any pair of negatives, if the details of the cancellous bone structure at the suspected point of fracture can be clearly made out and no fracture can be seen in the stereoscope, there is no fracture present. It is in doubtful cases that stereoscopic negatives furnish the most valuable evidence.

The difficulty of detecting fractures with displacement in only one plane can of course be overcome by taking two pictures in planes at right angles one to the other. This measure does not always overcome the difficulty in impacted fractures or in incomplete fractures, and in these cases stereoscopic radiographs furnish, in many instances, the only reliable, and sometimes the indispensable, data for a correct diagnosis.

With pictures taken and viewed singly, unless the rays fall in such a manner as to show some displacement or some actual space between the fragments of bone the fracture may entirely escape detection; that is to say, to make the matter more clear by an example, let us assume that a patient has a transverse fracture of the lower end of the radius with only a little dorsal displacement, and that a picture is taken in the ordinary way by placing the hand and forearm, palm downward, upon the photographic plate. If the anode of the tube is placed directly above the point of fracture, the break in the bone may or may not show upon the negative; if the anode of the tube is placed a few inches above or below the vertical dropped through the point of fracture, the point of view becomes an oblique one; the outlines of the bone structure will overlie one another in such a manner that the fracture will probably escape observation in the negative. If stereoscopic pictures of the same fracture are taken, from no matter what position of the anode of the tube, *the fracture and the displacement will stand out as plainly in the stereoscopic image as though one viewed the bared bone with the naked eye.* When, however, we attempt to produce radiographs of such a quality in pictures of the adult hip-joint, we often fail to obtain the minute details of bone structure necessary for a diagnosis in cases where there is little or no displacement, or where the fracture is impacted without much change in the normal outline of the bone. Under favorable conditions we may succeed in producing a good enough negative for our purposes, but if the individual is large and stout, the difficulties are at times very great. This is notably true of stout women the thickness of whose buttocks raises the skeleton some distance from the underlying table.

The general statement may then be made that, whenever the details of bone structure can be shown, the detection of fractures, wherever situated, admits of almost absolute accuracy. When a picture of this quality is for any reason not obtained, a fracture may still exist and not be evident in an X-ray picture.

Separation of the epiphyses, when these are still united by a layer of cartilage to the shafts of the long bones, can be detected whenever the separation is attended by displacement, otherwise not, since cartilage casts a very faint shadow, indeed so faint that the detection of loose portions of cartilage not containing deposits of earthy salts is quite impossible.

One of the results of the very general use of the X-rays in the diagnosis of fractures has been to demonstrate the fact that a perfect functional result is compatible with a good deal of displacement of the bony fragments; and, further, that the best efforts of skillful surgeons sometimes fail to reduce the displacements of simple fractures. This is so far true that it is sometimes unwise to permit patients to see the radiographs of their healed fractures lest, although the function of the limb may be in every way good, dissatisfaction may result when the patient realizes that the fragments of the bone are not in their true anatomical relations. Many suits for damages have been brought on these grounds alone.

The X-ray Diagnosis of Dislocations.—While the recognition of dislocations is generally quite easy by the ordinary methods of examination, it sometimes happens that in the particular case a doubt may exist as to the character of the dislocation, or as to whether a fracture coexists or not. In these cases X-ray pictures, and especially stereoscopic X-ray pictures, afford valuable aid. It is clear from what has already been stated that in dislocations the true relations of the displaced bones must be perfectly evident when viewed stereoscopically, and, indeed, experience shows that this is the case; the bones stand out in their true relations, and the diagnosis of the displacement can be made at a glance. In order to make the correct diagnosis of dislocations uncomplicated by fractures it is not necessary to obtain a picture showing bone structure. Very thin negatives, indeed, suffice; and, oddly enough, two negatives, neither one of which is good enough to base any conclusion upon at all, will, when united as a stereoscopic image, afford a surprising amount of information.

The X-ray Diagnosis of Deformities of Bone.—It goes without saying that gross deformities of bone, arising from ancient injury or from disease, can be very clearly shown in X-ray pictures; this is also true of congenital deformities —club-foot, for example. In cases where the relations between the smaller bones are disturbed, or where one or more bones remain undeveloped, or where supernumerary bones exist, or where one or more bones are wanting—stereoscopic pictures of such deformities give a far better idea of the relations of the parts than even dissected specimens, because the bones are seen as they exist in life while acted upon by the muscles and held in position by the ligaments. In cases of imperfect or arrested development of the skeleton, quite unsus-

pected degrees of difference between the size, shape, and position of the bones of the two sides of the body may be revealed by the X-rays.

(*b*) X-ray Diagnosis of Diseases of Bone

The various diseases of bone involving changes in the bone structure, such as rarefying osteitis, osteosclerosis, caries, necrosis, the productive inflammations of bone (syphilitic or other), tumors of bone (whether productive or destructive), loss of substance in bone, may in the more accessible parts of the body be shown, and even diagnosticated with considerable accuracy, by means of the X-rays.

In rarefying osteitis the shadow cast by the bone is not only less dense, but the increased size of the spaces in the cancellous tissue is easily recognized. The increased density and thickness of the cortical layer, the diminished size or absence of a medullary cavity in bones the seat of osteosclerosis, are often easily recognized in a good radiograph. Tuberculous cavities in the bones of children and tuberculous sequestra can often be seen with exquisite clearness in good pictures, and the diagnosis of these bony lesions is sometimes to be made with perfect accuracy, even without the confirmatory evidences to be seen and felt in the soft parts surrounding a joint. The detection of cavities or of tuberculous sequestra in the articular extremities of the long bones is sometimes possible before the invasion of the surrounding soft parts or of the joint structures has occurred—i. e., at a most favorable time for operative removal.

In syphilitic and other productive inflammations of bone the character and extent of the lesion can often be shown clearly. The character of tumors of bone, whether composed of dense or porous bony tissue, and the size, position, and structure of the attachment of the tumor to the healthy bone, can be readily made out in most instances. In the destructive tumors of bone the thickness and character of the bony layer surrounding the tumor, the amount of destruction of bone tissue, and even the limits of the infiltration of the bone with tumor tissue, can in the majority of instances be appreciated quite well. I was able in one case to demonstrate fairly well the presence of an osteosarcoma growing from the anterior surface of the sacrum.

(*c*) The Detection and Location of Foreign Bodies by Means of the X-rays

Metallic bodies, pieces of glass, and any mineral substance, whether in the form of a solid mass or a powder, may be detected when embedded in the tissues in most instances with ease. The exact location, however, of such a foreign body is a different matter. There are certain facts to be borne in mind: the nearer the foreign body is to the plate, the more sharp will be its shadow and the nearer will the shadow be to the actual size of the body; the farther away from the plate the more the shadow will be distorted and increased in

size, so that if a body of known character and size appears sharp and clear in the negative, it cannot be far from the skin surface which lies next the plate. The simplest way to locate a foreign body such as a needle or a bullet is to take stereoscopic pictures of the part containing the body. By this means the body may be located in many instances with sufficient accuracy to permit the surgeon to cut down upon it readily enough. The depth of the body from the surface and its relation to the bones can be clearly appreciated in the stereoscopic image. Another method is to take two pictures in planes at right angles one to the other. By measurements taken from bony points to the position of the shadows of the foreign body, and by measurements from the shadow of the surface of the limb, the position of the body may be determined.

The Mackenzie Davidson Localizing Apparatus.—Various ingenious methods and forms of apparatus have been devised for locating foreign bodies accurately. Among the best of these is the localizing apparatus of Mackenzie Davidson. The principle of this apparatus is as follows: The part containing the foreign body is placed upon the photographic plate, a picture is then taken, the tube is then moved a known distance horizontally and a second picture is taken without moving the part pictured upon the plate. Two shadows of the foreign body are thus cast upon the same plate separated by a distance which depends upon the distance of the tube from the plate, the distance the tube has been moved horizontally, and the distance of the foreign body itself from the plate, or, in other words, the depth at which it lies buried in the tissues. Mr. Mackenzie Davidson fastens threads to a horizontal bar separated from the negative below by a distance equal to the distance of the anode of the tube from the plate at the time the exposures were made; the threads are then brought in contact with some particular point of the shadow of the foreign body upon the negative placed below. The second thread is placed upon the corresponding point of the other shadow of the foreign body. The point of intersection of these threads indicates the position of the foreign body with reference to the photographic plate when the exposures were made. A full description of the apparatus will be found in "The Roentgen Rays in Medical Work," David Walsh, M.D., Edin., 2d edition, 1899, William Wood & Co., p. 93 *et seq.* By means of this apparatus foreign bodies may be located with absolute accuracy. For many purposes so accurate a localization is unnecessary.

Dr. Sweet's Localizer.—Dr. Sweet has devised a localizer for the purpose of detecting and locating foreign bodies in the eye. It may be used for locating foreign bodies in the brain. I quote Dr. Sweet's description of the apparatus, together with the method of its use (*Trans. of the Amer. Surg. Assn.*, vol. xxi, 1903, p. 479 *et seq.*):

The methods employed in locating foreign bodies by the Rœntgen rays are all based upon the triangulation of the planes of shadow of the body, with the X-ray tube in two different positions. Measurements of the distance of the crossing of

these planes from one or more points marked upon the skin give the exact situation of the foreign substance.

Accuracy of localization depends upon a knowledge of the position of the tube at the two exposures, its distance from the photographic plate, and upon the proper marking of one or more spots upon the skin by opaque substances that will cast shadows upon the plate. A special form of apparatus achieves these results in the most satisfactory manner.

The apparatus for locating foreign bodies is similar in principle to that employed so successfully during the past few years in determining the situation of pieces of metal in the eyeball. I have recently designed a new form of localizer, which is shown in the accompanying illustrations. It consists of a firm base, the top of which is covered with sheepskin, and is crossed by two steel wires at right angles to each other. A sliding drawer on one side permits the changing of the photographic plate without disturbing the position of the patient. A hollow upright bar attached to one side of the base supports three movable rods. One rod has its extremity pointed, over which slips an indicating ball. The other rods are employed to indicate the situation of the tube at the two exposures. The center of the indicating ball is directly above the crossing of the two wires on the base, and its height is shown by a scale upon the upright bar.

The head or other portion of the body containing the foreign substance to be located rests upon the top of the base portion, the cross wires, previously inked, leaving a mark upon the skin. The indicating rod is lowered until the ball rests upon the skin, and this spot is also indicated with ink. The distance of the ball above the cross wires is read from the graduated scale.

The X-ray tube is placed from eighteen to twenty inches above the plate, and the distance of the anode of the tube carefully measured. One exposure is then made with the tube directly above or to one side of the indicating ball, and a second plate made with the tube from three to four inches from the first position.

After development the plates show the shadows cast by the cross wires, the indicating ball, and the foreign body. The distance of the foreign substance from the marks upon the skin of the patient may be determined by plotting upon a flat surface the position of the tube, indicating ball, and the cross wires at the two exposures, and finding the crossing of the planes of shadow of the foreign body. This method is the one employed in eye work, and is equally accurate in dealing with other portions of the body, although somewhat more complicated. For this reason I have employed threads to indicate the crossing of the planes of shadow in the new localizing apparatus—a method which has been developed by Mackenzie Davidson, of London.

The method of employing the indicating apparatus is as follows: A tracing of the two negatives is made upon a transparent sheet of celluloid, with the point of crossing of the wires corresponding. This celluloid sheet is placed upon the top of the base of the apparatus with the tracing of the shadow of the cross wires directly above the point of crossing of the wires. The indicating rod is moved to the height it occupied at the time the exposures were made. A thread is now passed from the spot on the celluloid representing the shadow of the indicating ball at one exposure, touches the point of the indicating rod representing the center of the ball, and is continued the exact distance that the tube was away from the plate when the radiograph was made. A second thread passes in the same manner

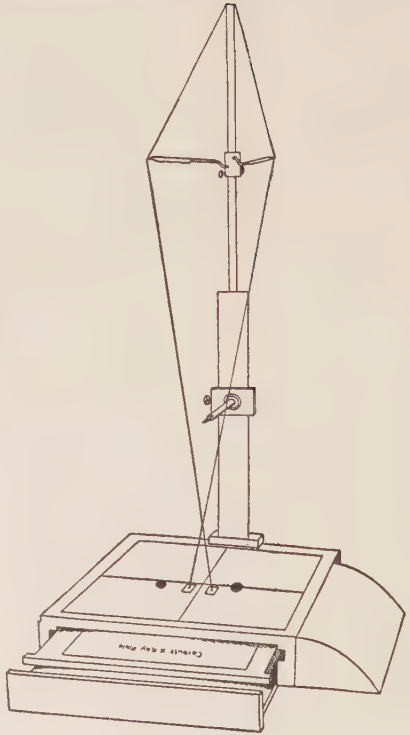


FIG. 130.—DR. SWEET'S LOCALIZING APPARATUS. Planes of shadow represented by threads, the point of crossing of which indicates the situation of the bullet.

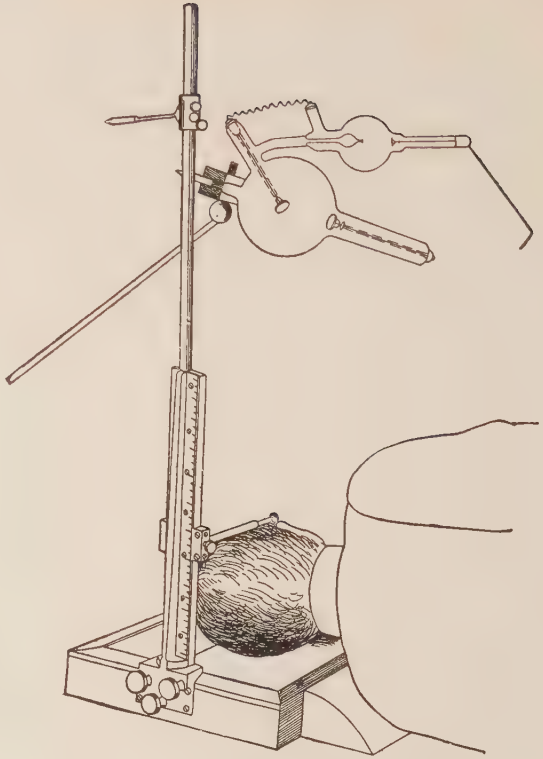


FIG. 131.—SIDE VIEW OF APPARATUS, SHOWING INDICATING ROD AND GRADUATED UPRIGHT.

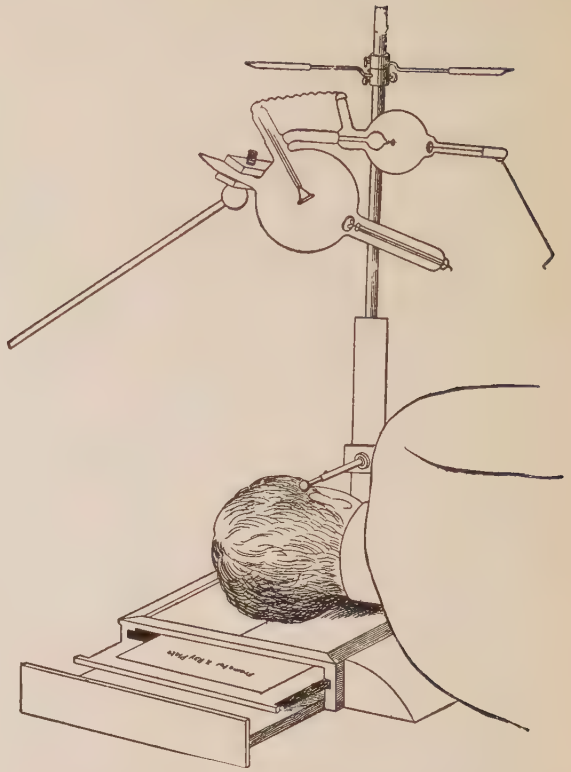


FIG. 132.—SIDE VIEW OF THE INDICATING APPARATUS, SHOWING POSITION OF TUBE AND INDICATOR, AND ALSO RECEPTACLE FOR THE PHOTOGRAPHIC PLATES.

from the shadow of the indicating ball at the second exposure. The threads are kept taut by lead weights in the hollow upright tube. These two threads accurately indicate the lines of shadow of the indicating ball at the two exposures, and also the position of the tube. If the ends of the threads resting upon the shadows of the indicating ball are now moved to the spots on the transparent celluloid representing the shadows made by the bullet, their crossing will show its position in the tissues in relation to the indicating ball and cross wires. The distance of this point of crossing from the indicating ball gives the location of the body in the tissues as measured from the spot on the skin at which the ball rested when the two plates were made. The situation of the bullet may also be measured from the cross wires. The depth of the body will determine which of the two points is to be chosen in plotting the position of the body for operation. The location of each fragment of the bullet is similarly determined.

The apparatus was made for me by Queen & Co., of Philadelphia.

(*d*) The Recognition of Tumors and Diseases of the Soft Parts by Means of the X-rays

Large aneurisms, cysts, enlarged kidneys, and abscesses may often be demonstrated clearly by means of an X-ray picture. It is necessary to use a tube of rather low resistance in order to show slight differences in the den-ity of the structures penetrated. It sometimes happens that the course of a suppurating tract in the tissues is difficult to follow by ordinary means. If such a tract can be injected with an emulsion of bismuth, it can often be shown in its entirety by means of a radiograph whether it be situated in the soft parts or in bone. The boundary of a dilated stomach can be quite clearly shown by the administration of a considerable quantity of bismuth emulsion by the mouth. A more general application of this method will readily occur to surgeons in suitable cases. The size of solid and cystic tumors of the abdomen can often be determined by means of an X-ray picture.

(*e*) The Detection of Pathological Concretions.—Stone in the Kidney, Ureter, Urinary Bladder, and Biliary Calculi

While it cannot be said that the X-rays are an infallible means of detecting the presence or absence of calculi in the kidney, in the ureter, and in the urinary bladder, still the accumulated experience of many observers leads to the conclusion that the X-rays furnish a certain means of diagnosis, positive and negative, in a large proportion of cases. The limitations of the X-rays in this field are due partly to the character of the stones themselves, partly to imperfections, hitherto unavoidable, in the apparatus employed, partly to errors of technic, including the faulty use of the X-rays, the imperfections in photographic plates, and errors in the interpretation of the developed photographic negative.

Chemical Composition of Kidney Stones.—We may first consider the difficulties due to the chemical constitution of the stones which we wish to detect.

Chemical examination of any large number of kidney, ureter, and bladder stones shows that they consist mainly of three sets of ingredients, namely, oxalate of lime, uric acid, and the phosphates of the alkaline earths. In addition to these common ingredients we find, rarely, stones composed of cystin of sulphur and of indican; these last are, however, so rarely present that for practical purposes they may be excluded. The stones originating in the pelvis of the kidney—unless the kidney is already the seat of inflammatory disease

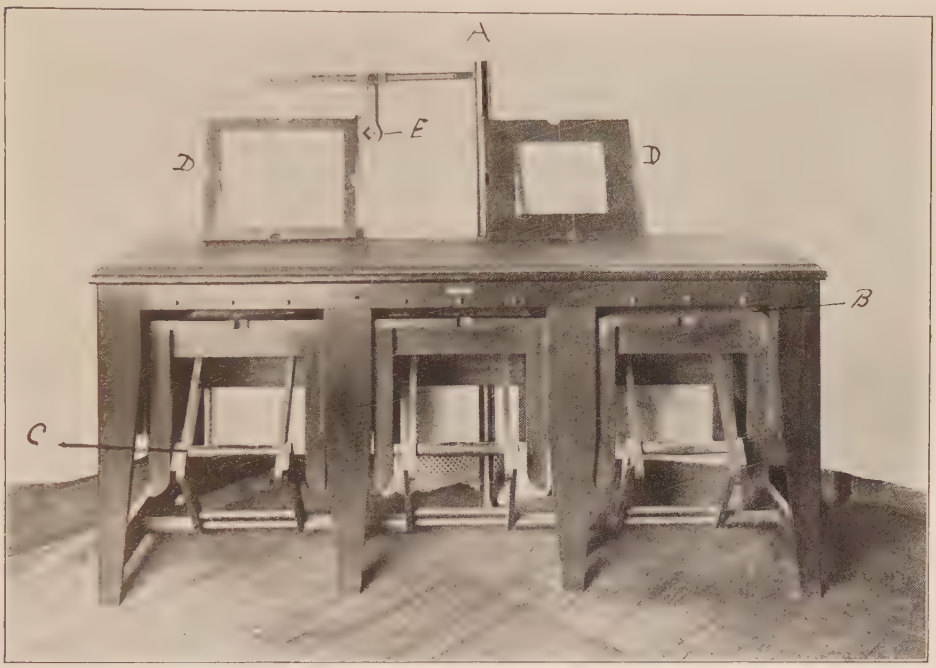


FIG. 133.—AUTHOR'S X-RAY TABLE FOR TAKING STEREOSCOPIC RADIOGRAPHS. In the position shown in the illustration the three drawers for the reception of photographic plates are shown open as at B. Upon the table are standing two kits for holding photographic plates of 8 × 10 and 11 × 14 inches; when no kit is used the drawer admits a plate of 14 × 17 inches (D). At C is shown the toggle-joint by which the photographic plates are pressed firmly upward against the pegamoid covering of the table and by means of which, after an exposure has been made, the photographic plate can be moved and replaced by another without in any wise disturbing the position of the patient. At A is shown the vertical wooden pillar, together with its horizontal arm, both graduated in inches for holding the X-ray tube. At E is shown the wooden clamp which grasps the tube. By means of this arrangement it is possible to place the tube readily a measured distance above the photographic plate, or to move the tube horizontally, for the purpose of taking stereoscopic pictures. The table was made for me by the Folmer & Schwing Manufacturing Company, of New York. In use it has been found very satisfactory.

causing its own symptoms of a character sufficiently marked to overshadow the symptoms produced by the stone itself—consist of oxalate of lime, uric acid, or both. We further find that stones consisting chiefly of uric acid contain a fairly large proportion of oxalate of lime, and that pure oxalate stones without any uric acid are of comparatively rare occurrence.

I collected a considerable number of stones from various sources supposed to contain uric acid and nothing else; they were subjected to chemical examination, and it was found that although a very few consisted of uric acid alone,

nearly all contained ten per cent or more of oxalate of lime. A series of experiments were then conducted by placing stones of various sizes and of various and known composition upon photographic plates along with portions of human ribs, a finger, biliary calculi and stones inclosed in masses of muscular tissue and in recently extirpated human kidneys; these plates were then exposed to X-rays emanating from tubes of various penetrating qualities, for different times and with different quantities of electrical energy. The results of these experiments were to show that oxalate of lime stones cast very dense shadows; the same was true, to a somewhat less degree, of phosphatic stones. It was further found that in the case of uric-acid stones, containing even ten per cent of oxalate of lime, the shadows were still quite dense. Pure uric-acid stones, on the other hand, appeared to be very permeable to the X-rays; the shadows cast by them were faint and were readily blotted out; the same was true, and to nearly a like degree, of biliary calculi.

Conditions Necessary for Success and Limitations of the Method.—In order to detect successfully a stone in the pelvis of the kidney it is necessary to produce a negative which shall show distinctly the additional density of the stone as compared with the shadow cast by a very thick portion of the human body; and, as a matter of practical experience, it is found that oxalate-of-lime stones, phosphatic stones, and uric-acid stones, containing some proportion of oxalate, can, whether in the ureter or kidney, under ordinary conditions be detected with a fair degree of certainty, even though they are of small size; biliary calculi and uric-acid stones, on the other hand, cannot.

In a man weighing one hundred and seventy-five pounds I was able, on three successive occasions, to detect an oxalate stone, weighing one grain, in the ureter. The stone was passed *per urethram* soon after the last picture was taken. The progress of the stone down the ureter was clearly shown in the successive pictures. In a rather slender girl of sixteen a stone weighing one half grain in the renal pelvis was clearly shown upon the plate. The stone was removed, with another larger stone, by operation, and was found to consist of equal parts of uric acid and oxalate of lime.

When the individual is large and stout and has a thick abdomen, the difficulties are enormously increased: longer exposures are needed to penetrate the body, the stone itself is much further removed from the photographic plate, and there are apt to occur vague and ill-defined shadows, rendering a correct interpretation of the plate impossible. It is true that improved apparatus has rendered the number of failures smaller, but many still occur. It is found that in these cases the best results are obtained by forcing the largest possible amount of current through the tube for a short time rather than by using less current and a longer exposure. In this way, with the best obtainable tubes and a coil giving a very heavy discharge, pictures of kidney stones may be taken in a minute or less. At the end of this time the vacuum of the tube usually breaks down and ceases to furnish rays of sufficient penetrative power.

In certain instances errors in the development of the plate may destroy

its value. If the plate has been sufficiently exposed and is developed too far the shadow of the stone may be blotted out. The best pictures are usually obtained with tubes of not too great a penetrative power, furnishing rays that show the greatest possible amount of gradation in the shadows of the tissues. A tube which gives a fluoroscope picture of the hand so bright that the bones are nearly blotted out is not as suitable, according to my experience, for showing the slighter differences of density as is a tube of lower vacuum. The experience of some observers seems to differ from mine upon this point, and I should not wish to make my assertion too positive. The quality of an X-ray picture necessary to enable one to exclude the presence of stones in the kidney or ureter should be such that the transverse processes of the lumbar vertebræ, the last two ribs, the borders of the psoas muscles on either side of the vertebræ, show sharply and plainly. The shadow of the stone itself will, if in the pelvis of the kidney, be found a little below the last rib and about two and one half inches from the spinal column. If the stone is large, a very distinct shadow will be cast, so that sometimes the weight of the stone may be guessed at within a few grains.

In poorer negatives the shadow may be very faint, and special methods of illumination are necessary in order properly to interpret the plate. For the study of such negatives, and as a convenient method of examining any X-ray picture, a cubical metal box is used the top of which is composed of opal glass; in the box are several electric-light bulbs; an X-ray negative is laid upon the opal glass and the interior of the box illuminated; in this way the lights and shadows of the plate can be studied to the best advantage. In case a shadow is found suggesting the presence of a stone, a second picture should be taken to confirm the diagnosis, for the reason that imperfections in the film or in the impregnation with the silver salt may give rise to shadows closely resembling those made by stones, and further similar shadows are sometimes cast by hardened masses of intestinal contents (these may be avoided by having the bowel thoroughly emptied before the picture was taken). Should the second picture, taken after an interval of several days, show a shadow identical in size and position with the first, the diagnosis of stone is reasonably sure.

If no shadow is seen resembling a stone, what is the value of the negative diagnosis? If the quality of the picture is excellent and the individual is not notably stout, the presence of an oxalate or phosphate concretion may be excluded with reasonable certainty. In those cases, however, in which the pelvis of the kidney contains minute phosphatic concretions arranged irregularly in amorphous masses, no definite shadow may be produced. If the stone consisted of pure uric acid it would probably, in my experience, fail to cast a definite shadow; certain skillful observers have, however, succeeded in identifying pure uric-acid stones.

Stone in the Ureter.—The lower one third of the ureter is the portion in which stones ordinarily become impacted. They are commonly found in the

negative below the lower border of the ischium, and rather near the outer border of the sacrum. For detecting stones in the lower portion of the ureter it is best to place the anode of the tube over the umbilicus, or even a little lower down. A frequent source of error is the appearance upon the plate of sharply marked, rounded shadows, varying in size from that of a No. 5 shot to that of a dried pea; these shadows are, however, placed usually farther away from the middle line than the course of the ureter; they often appear near to and upon a level with the spine of the ischium, sometimes lower down, and in one instance they appeared to lie in the region of the prostate gland. The nature of these shadows has not, as far as I am aware, been determined; they may represent concretion in the veins or in the ligaments; they occur in both men and women; I have not observed them until the fourth decade of life. In my own experience, stones in the ureter are easier to detect than in the kidney.

Stone in the Urinary Bladder.—Stone in the urinary bladder may be discovered so readily by other means that it is rarely necessary to resort to the X-rays for a diagnosis. X-ray pictures of bladder stones are, in my experience, uniformly successful. The tube may be placed in the same position as is used for the detection of stone in the ureter.

Experience in Detection of Renal and Ureteral Calculi.—My personal experience in detecting renal and ureteral calculi is embodied in the following extract from a paper I wrote on this topic several years ago:

My own experience is limited to about 125 cases examined. I have not succeeded in detecting a pure uric-acid calculus. Among the earlier cases examined was one in which, owing to want of experience, a shadow upon the plate was believed to be a stone, but was found to be due to a defect in the gelatin. The patient was operated on and no stone was found. In thirty cases a positive diagnosis was made by means of one or more skiagraphs, and the presence of stone was confirmed by the operation.

Of the stones discovered, in twenty-six cases the stone or stones were in the pelvis of the kidney or extreme upper end of the ureter. In four cases the stones were in the pelvic portion of the ureter.

One stone of oxalate of lime weighing less than a grain and a half was found on three different occasions in the ureter, each successive time at a lower level. The stone finally passed and was weighed by me. As stated, it weighed one and a half grains. The patient suffered no further discomfort. He was a man with a thick abdomen, but of short stature. His weight was 175 pounds.

The stones discovered have varied from a fraction of a grain to nearly an ounce in weight. They have all either contained oxalate of lime in appreciable quantity or have consisted largely of phosphates. Several stones appeared to consist of uric acid merely, but chemical analysis showed at least ten per cent of oxalate of lime in every instance.

In several cases no picture has been obtained good enough for a diagnosis. The failures have been due to:

1. Great thickness of the body of the patient.
2. Imperfect working of the electrical apparatus.
3. Improper handling of the photographic plate in the dark room.
4. Imperfect photographic plates.

Among the cases in which a negative diagnosis has been made, in one I failed to detect the presence of several small calculi in the end of the ureter. In this case the X-ray plate did not extend far enough downward to include that portion of the ureter in which the stones were afterwards felt *per vaginam.*

While I do not intend to enter into an elaborate description of the apparatus and the technic employed, I believe that a general view of the methods, the difficulties, and the apparent limitations of the procedure at the present time may not be devoid of interest.

To insure success in the radiography of kidney stones, the following conditions must be fulfilled:

The electrical current used to excite the tube must be of high voltage and of considerable ampèrage. The best coils and large static machines answer this requirement perfectly.

The X-ray tube used must permit the passage of such a current continuously for several minutes without much change in internal resistance, and to produce the best effects this should be true, although the resistance or vacuum of the tube is relatively low at the start. This condition is, in my experience, hard to fulfill.

A tube of relatively low resistance produces rays showing upon the photographic plate slighter differences of density in the structures through which the rays are passed, but as the result of the passage through such a tube of a powerful current, the tube usually becomes heated with a further fall of resistance and the production of rays of inadequate penetrative power. A tube of high resistance tends to preserve its vacuum resistance better, but the X-rays given off from a tube the resistance of which is very high possess the penetrative power to a high degree; they penetrate all the structures of the body more nearly in an equal manner, and thus produce radiographs showing but little contrast between tissues of different densities. Such pictures are what are described in photography as "flat" negatives. The positive and negative value of such a picture of the body of an individual supposed to be suffering from renal calculus is not great.

In order to establish the absence of stone it is necessary, as has already been pointed out by a number of observers, to produce a negative which shall show such marked contrasts between structures varying but little in density that even the smallest calculus will cast a definite shadow. This may usually be done in young persons and in slender adults. It is, on the other hand, exceedingly difficult when the individuals are large and stout.

I have been unable to make up my mind as to the exact cause of this difficulty. Probably pictures of fat people are hard to obtain for several reasons.

In the first place, the actual thickness of tissue to be penetrated is much greater, consequently the exposure must be longer; moreover, the length of the exposure must be still further increased, because it is dangerous to expose the skin for a long period to the action of the rays unless a considerable interval exists between the tube and the skin—twelve inches at least. There seems to be some reason to believe that long exposures excite in the tissues themselves secondary foci of X-rays, which affect the photographic plate and produce a blurred and indistinct picture.

The thickness of the fat upon the buttocks and upon the back raises the skeleton and the kidney some distance away from the underlying photographic plate. A further blurring and want of detail in the image is thereby produced. This is notably the case in women possessing thick buttocks.

The movements of the abdominal walls of fat persons also seem to produce a clouded appearance on the photographic plate, as well as the respiratory movements of the kidney itself.

I have succeeded occasionally in producing satisfactory negatives of very stout people. The conditions were as follows: The tube used was the water-cooled tube devised by Dr. E. Grünmach and sold by the Kny-Scheerer Company. It has always happened to be an entirely new tube, of relatively low resistance, showing a brilliant apple-green fluorescence and illuminating the fluoroscope brilliantly, and producing vivid fluoroscopic images of the flesh and bones of the wrist and forearm. Such a tube will produce a vivid picture of the hand on the screen at a distance of many feet, and the tube has always possessed the peculiarity that its resistance fell but little even after some minutes of running at its full capacity.

I have never taken a successful picture of a kidney stone with a tube which had been used many times, or with one which had become coated with the purplish-black film which forms in old tubes. My best pictures have been taken with the Wehnelt electrolytic interrupter, with rather a heavy platinum electrode having a considerable amount of platinum exposed in the acid, thereby permitting the use of a current of considerable ampèrage and relatively slow interruptions.

The exposures for large, stout people have varied from ten to fifteen minutes with the anticathode about thirty inches from the photographic plate. For thin individuals these exposures have been shortened one half.

I do not know whether my failure to obtain good pictures with any but new tubes is due to a defect in the apparatus used or not, but I am inclined to think that such is the case, since the experience of others does not entirely agree with my own.

This may depend upon the fact that with the machine I used a discharge occasionally occurs through the tube in both directions. Hitherto I have been unable to prevent this when driving the tubes to their fullest capacity, and they are soon destroyed.

It has sometimes happened that with all the conditions apparently favorable, and with the greatest pains in technic, the pictures have been utter failures.

Sometimes I have been able to account for such failures by imperfections in the photographic plate or in the technic of development, and sometimes I have not been able to explain the failure. A serious handicap has been also, in these cases, the necessity of taking the pictures singly and at rather long intervals, on account of the danger of burns and of the unwillingness on the part of the patients to permit a number of exposures to be made. The very great expense also of new tubes for each case has prevented the best obtainable results.

The conclusions I have been able to draw from my experience are as follows:

The positive diagnosis of kidney stone by the X-rays is reliable and of great practical value.

The negative diagnosis of kidney stone by the X-rays is reliable and valuable up to a certain limit.

If pictures of a proper quality are obtained, calculi of oxalate of lime and phosphates can be excluded. Pure uric-acid calculi cannot.

Pictures of a proper quality can be obtained with ease in children and slender adults of both sexes.

Such pictures can usually be obtained by repeated trials in well-nourished adults.

When patients are unusually stout, when the abdomen is very thick and the buttocks are large, the conditions are extremely difficult, and only occasionally will a satisfactory result be obtainable with the present form of apparatus.

Biliary Calculi.—A few successful results in the detection of biliary calculi by means of the X-rays have been reported by Dr. Carl Beck. My own efforts in this direction have been failures. If the individual were slender and the calculi numerous or large, and situated in the gall-bladder, it would seem reasonable to suppose that they might be detected in some cases by placing the patient on his stomach with the plate beneath the region of the gall-bladder. A tube of low vacuum should be used in order to show the slightest differences of density, and the exposures should be short, for fear of blotting out the shadows of the stones altogether.

As far as I am aware, no successful efforts have been made to detect the presence of concretions in the vermiform appendix. Lying, as it does, in the iliac fossa, when normally placed it would overlie, in the picture, a dense mass of bone, a position not favorable for the detection of slight shadows.

(*f*) The Injuries Produced by the Diagnostic Use of the X-rays upon Patients and upon X-ray Operators

During the earlier years of the diagnostic use of the X-rays a good many serious injuries occurred from want of experience; at present improved appa-

ratus have so shortened the duration of exposures that X-ray burns rarely occur, except as the result of the therapeutic use of the rays, and among those who are frequently exposed to the rays for long periods. The shortest single exposure followed by a burn in my own experience lasted seven minutes with the tube distant twelve inches from the skin; a moderate dermatitis followed in five days. Several burns have been produced by exposures aggregating thirty minutes upon the same, or upon successive days, but none of these were severe. On the other hand, patients have been exposed for therapeutic purposes for ten minutes daily for six weeks, with the tube not more than six inches from the skin, and no burn, other than slight tanning, has appeared. There is probably a personal idiosyncrasy which renders some persons more susceptible than others. The color or quality of the skin does not appear to bear any relation to this susceptibility. It is generally believed that tubes of low resistance and rays of low penetrative power are more apt to produce burns.

Various observers have asserted that burns might be prevented by interposing between the tube and the skin a screen composed of a thin sheet of metal —gold leaf spread upon wood or a thin sheet of aluminum; I have not found that the use of these screens prevents burns absolutely, although I believe the danger of a burn is somewhat diminished. Anointing the skin with lanolin or vaselin has been suggested as a means of preventing dermatitis; I have not found them effective in all cases. With the large coils and tubes in use at present, and with exposures lasting from a few seconds to two minutes, dermatitis is scarcely likely to follow. Damage suits have been brought against many surgeons to recover on account of X-ray burns produced during radiographic exposures; they have not been successful in any instance as far as I am aware. It has been generally held by the courts that if the plaintiff knew that a burn might follow the exposure, and accepted the risk, the surgeon could not be held responsible. It is, however, wise when about to expose a patient to the X-rays for diagnostic purposes to expressly warn him in the presence of witnesses that a burn may follow. An agreement in writing to the effect that the risk is accepted by the patient is desirable; such an agreement might not prevent a suit, but would, doubtless, go far to invalidate a claim for damages. The surgeon should avoid making repeated exposures upon the same or successive days, and in any case when the aggregate time of exposure for one or more pictures is five minutes or more, it is well to wait ten days before subjecting the patient to the influence of the rays a second time. These remarks do not apply to the therapeutic use of the rays, since frequent exposures are necessary, and the danger of a burn is generally understood and accepted by the patient. It is wise during all exposures to protect those parts of the body not to be included in the picture by thick sheets of lead, insulated from the patient's skin by towels or the like.

X-ray Burns.—The irritating and destructive effects of the X-rays upon the tissues vary to some extent, according to whether the individual is exposed only a few times, with a short interval between, so that the cumulative effect of the

rays produces a single destructive lesion, or whether, on the other hand, the exposures are short, very numerous, and extend over a long period of time. In the former category belong the X-ray burns produced in patients; in the latter, the injuries suffered by surgeons and other X-ray operators who are exposed to the rays in the course of their work for long periods.

Burns After Single Exposures.—As the result of a single exposure or of several exposures at short intervals, the injurious effects of the rays appear after from four days to two weeks from the time of exposure. In the mildest cases the patient suffers a burning pain in the exposed part; the skin becomes reddened, hot, and tender; slight vesication may appear after a few days. The vesicles are minute and soon dry, forming crusts. The hair upon the part usually falls out. At the end of ten days or a fortnight the burning, redness, and tenderness gradually subside, and although the patient may feel a little pain for a week or more longer, the injury gets well, and leaves no serious effect behind except the loss of hair, and in some cases a moderate amount of brownish pigmentation of the skin. The hair grows again in the course of a few months.

If the injury is more severe the patient begins to suffer intense burning pain, followed shortly by a well-defined area of redness and exquisite tenderness. Large vesicles form upon the surface, and the reddened area assumes a dark purple or magenta color. The vesicles become confluent, their contents become cloudy, and within a week or ten days from the commencement of the symptoms the horny layer of the skin separates over a considerable part of the burned area, leaving behind an exceedingly tender raw surface, on the level with the surrounding skin, from which escapes a moderate amount of thin watery discharge. The raw surface is bright red in color, becomes covered in a few hours with a thin, delicate, soft pellicle or scab. If this pellicle be wiped away, the surface beneath bleeds readily. The lesion is characterized by continuous and fairly severe pain, by exquisite sensitiveness, and by extreme slowness of the healing process. The epidermis grows in from the edges. Such a raw surface, three or four inches in diameter, may require many months to heal. The scar left after such a burn may remain sensitive and painful for some time. It is usually white in color, smooth, occasionally pigmented; telangiectasis may follow.

Burns of a more severe character than this, as the result of the diagnostic use of the rays, are at present practically unknown. Soon after the X-rays came into general use a few of these burns were produced. The early symptoms were those just described, but the destruction of tissue involved the entire thickness of the skin and sometimes the deeper tissues. A white, tough, and leathery slough was gradually formed on the burned area. The lesion was so horribly painful that these unfortunates usually acquired the morphin habit. The vitality of the deeper tissues was impaired, so that no sharp line of demarcation formed between the living and the dead tissues. There seemed to be little or no tendency for the dead material to separate itself from the living, and if

removed by operation an unhealthy raw surface was left behind, which sometimes existed for months without any apparent sign of healing. The condition sometimes lasted for years without much betterment, and amputation was necessary in several instances; in others an extensive plastic operation.

Chronic Disturbances Produced by Frequent Exposures to the X-rays.—The chronic effects produced by frequent exposures to the rays for long periods of time have been very frequent among those who have used the X-rays continuously, and have failed properly to avoid the unnecessary exposure of their hands. In the mildest form the skin upon the back of the hands becomes dry, slightly red, and scaly. The skin loses its elasticity, and when pinched up upon the back of the hand feels like leather. The hair falls. The hands have a somewhat red and congested appearance. If the exposures are discontinued the effects gradually pass away, and entirely disappear in a few months. If the individual does not heed this warning, the nutrition of the skin of the hand suffers profoundly. The nails become friable and their growth is interfered with; the free edge of the nail breaks off and leaves the end of the finger exposed, sometimes quite well down into the matrix. The nails are thinned, ridged, and furrowed transversely. Hard nodules form upon the knuckles, become fissured, and finally develop into shallow, sensitive, and intractable ulcers. The hands look blue and shriveled. If the individual ceases to be exposed, the condition of the hands may return to normal in six months or a year. If he persists, the condition grows slowly but steadily worse; the nutrition of all the structures of the hand suffers; the ulcerations become deeper and more extensive; the joints may be invaded, and the hand may finally become so crippled as to be useless.

Epithelioma.—Epithelioma has developed in several instances, and amputation of the fingers, and even of the upper extremity, has become necessary. In some cases it appears that the nutrition of the hand is permanently affected, so that the lesions are progressive after the exposures to the rays have ceased, and this, too, when the apparent severity of the condition was slight. Three deaths have been reported within the past year among surgeons and X-ray operators from recurrent epithelioma following amputation for the relief of the conditions above described. In several instances, also, epithelioma of the face has developed during, or after, the X-ray treatment for lupus.

Azoöspermia.—Azoöspermia is said to be a constant condition among those who are frequently exposed to the X-rays. As yet it is not definitely known whether or not the condition, once produced, is permanent, but instances are known to me where the condition has endured for more than a year. Recent observation has shown that the condition is, at least in some cases, probably not permanent. The condition is that impotentia generandi. Potentia cœundi is preserved. As a means of protection against the rays the following device is in use at present in the New York Hospital: A partition is built across the X-ray room and covered with heavy sheet lead. In the partition is a door, also covered with lead, except for a small window of lead glass. All the controlling

devices, switches, etc., are so placed that the X-ray operator, after arranging the patient, the tube, etc., retires behind the partition and controls the operation of the coil, tube, etc., entirely protected from the rays. Through the window he can observe the patient, the appearance of the tube, etc. It has been found necessary to carry the lead screen quite down to the floor and up to the ceiling, to avoid the influence of diffused or secondary rays.

CHAPTER XII

INJURIES AND DISEASES OF THE SCALP

SUBCUTANEOUS WOUNDS OF THE SCALP

Anatomical Peculiarities.—The injuries of the scalp may be subcutaneous or open wounds. The characters of contusions of the scalp are modified by the anatomical arrangement of the several layers of soft parts covering the skull. The skin is firmly attached by dense bundles of connective tissue to the underlying aponeurosis of the occipito-frontalis muscle or galea; hence, subcutaneous effusions of blood between these layers form circumscribed swellings, rather tense and prominent. Such constitute the familiar bumps on the head seen so often in children after blows and falls upon the head. On the forehead, in the temporal regions, and near the occiput, where the skin rests upon the frontal, temporal, and occipital muscles, the union between the skin and the underlying structures is less intimate and firm, and in these regions blood or other fluid beneath the skin is diffused more rapidly. The galea, on the other hand, is but loosely attached to the pericranium, and subaponeurotic fluid collections, whether blood or pus, tend to spread widely. The swelling produced is neither sharply defined nor tense. The *pericranium* is attached to the skull quite firmly along the sutures and at the sites of muscular attachments; hence, accumulations of fluid between the skull and its periosteum may be limited to a single bone, or in some directions by a tendinous insertion. These limitations are more marked in adults than in children. In children the vascular connections between the pericranium and the skull are more numerous, and subpericranial hematomata are very rare except during childhood or infancy.

Signs of Contusion of the Scalp.—The signs of contusion of the scalp vary, then, according to the anatomical site of the effused blood; if subcutaneous, a sharply defined rounded elevation appears immediately after the injury. The swelling is tense and elastic, and may fluctuate; if grasped in the fingers, the mass will be found to move with the skin. Immediately, or after a few hours, a characteristic discoloration of the skin develops; dark blue at first. After eighteen to twenty-four hours the margin of the ecchymotic area becomes lighter in color and of a violet shade. The subsequent color changes are brown, green, and finally yellow; the lighter colors appearing on the advancing border of discoloration as the blood pigment is diffused through the tissues. The swell-

ing soon disappears. The discoloration remains a longer or shorter time, according to the amount of effused blood and its situation. On the scalp, forehead, and eyelids it is usually quite gone in a few days; in the extremities, on the other hand, yellow pigmentation may be present for weeks. If, as the result of a contusion, blood accumulates beneath the galea, it spreads widely; the resulting hematoma may cover a large part of the skull. A boggy condition of scalp results if the amount of blood is moderate; if larger, a fluctuating, diffuse swelling of but little tension is found. Continued bleeding may cause the swelling to increase in size and extent for hours or days. Rarely—an artery of some size being torn—the tumor may pulsate. A traumatic aneurism or arterial hematoma may be found in rare instances, and arterio-venous aneurism has also been observed.

Examination of Hematomata.—In examining hematomata lying beneath the galea the following peculiarities are to be borne in mind: The tissues at the border of the hematoma soon become infiltrated with blood, and later with fibrin. As the examining finger passes across this border and depresses the scalp into contact with the skull, the bone may feel as though depressed. The true condition can be recognized by pressing and stroking the infiltrated border of the hematoma; the blood clot and fibrin are thus pressed away, and the sensation given to the finger of a depression in the skull disappears. Usually such hematomata are rapidly absorbed and disappear in a few days; in rare cases the fluctuating tumor may remain for several weeks. The introduction of an aspirating needle into the tumor withdraws partly disintegrated blood. Contusions of the scalp rarely produce a subperiosteal hematoma in adults. The lesion is more common in children, and the effusion is often limited to one bone or by tendinous insertions. The differential diagnosis from subaponeurotic hematomata is not easy.

Associated Lesions.—Hematomata of the scalp are often associated with the symptoms of Commotio cerebri, concussion of the brain, as well as with fissured fractures of the vertex. Definite symptoms of compression or laceration of the brain are not present unless the degree of violence was extreme. While hematomata of the scalp rarely require operative treatment, they may become infected through abrasions of the scalp or through severely contused skin areas which become necrotic. The surgeon will do well, therefore, to shave, disinfect, and protect the overlying skin. When infection occurs the diagnosis becomes that of abscess or phlegmon of the scalp. (See Phlegmon of the Scalp.)

Edematous Tumor of the Scalp in the New-born (*Caput succedaneum*).—During labor that portion of the presenting head not subjected to the uniform compression of the parturient canal becomes the seat of edema and ecchymosis. During the earlier part of labor, the edema takes place in that portion of the scalp encircled by the border of the cervix. The edematous area is circular. During the delay which occurs at the perineum the vulva may act in a similar manner; the edematous area is oval. Two such areas may thus exist on the

same head. If the membranes have remained unbroken, or the labor has been rapid, the tumor will be small or absent; if the pelvis is contracted or the labor long, it will be larger. At birth the scalp will be swollen and edematous over a rounded or oval area whose situation varies. In left occipito-anterior positions the tumor forms over the posterior-superior angle of the right parietal bone. In right occipito-anterior cases, over the corresponding point on the left side. In occipito-posterior positions the tumor will be over the anterior angle of that parietal bone which is turned toward the pubic arch. The color of the tumor is dark red or bluish red at birth, and if blood is extravasated into the tissues goes through the ordinary ecchymotic changes. Disappearance of both tumor and discoloration is rapid, and occurs after a few days. In cases where, owing to a large head or a shortened conjugate, the head is exposed to prolonged or severe pressure from the promontory of the sacrum, oval, rounded, or linear contusions, abrasions, and excoriations may be present at birth on that portion of the fetal head exposed to pressure.

Cephalhematomata of the New-born.—Pressure exerted upon the fetal head by the pelvic walls of the mother during labor may cause lacerations of the blood-vessels of the pericranium along the lines of the sutures, and stripping of the pericranium from the bone. Less often, the vessels beneath the galea are torn. Such lesions are said to occur once in two hundred labors. Bending, or actual fracture, of the cranial bones is a rare concomitant of this condition, and may be associated with intracranial hemorrhage. As the result of subpericranial bleeding a fluctuating tumor of some size may be observed at birth or after a few hours—commonly in the parietal region. They are to be differentiated from encephalocele from the fact that the latter occurs in the middle line. (See Encephalocele.) These hematomata soon develop the following characters: The fluctuating swelling has a sharply marked, firm border above the level of the included portion of skull, which, therefore, feels as though depressed; this is due to rapid production of bone tissue by the pericranium along the border of the swelling. The border of the hematoma is thus surrounded by a more or less completely ossified bony ridge. The blood is absorbed in ten days or so, and the pericranium again becomes attached to the skull. The new bone may also disappear in time or remain as a bony ridge or leave behind a series of small bony projections resembling Wormian bones on palpation. Infection of cephalhematomata produces the signs and symptoms of abscess, phlegmon, or gangrene of the scalp.

Traumatic Blood Cyst.—The regular history of hematomata of the scalp is that they are rapidly absorbed and disappear. Sometimes absorption does not occur, and a cavity remains, having a wall of connective tissue and containing a reddish-yellow more or less turbid or clear fluid. The history of an injury, the presence of a circumscribed fluctuating noninflammatory tumor upon the scalp, and the character of the fluid contents, as determined by aspiration, establish the diagnosis.

OPEN WOUNDS OF THE SCALP

Anatomical Observations.—The blood supply of the scalp is abundant. Scalp wounds usually bleed freely. The *arterial supply* of the scalp is as follows: The forehead is supplied chiefly by the frontal and supra-orbital branches of the ophthalmic artery. The supra-orbital artery emerges from the orbit at the supra-orbital foramen. The frontal artery emerges from the orbit at its inner angle. Laterally, and in front as well, the scalp is supplied by the anterior and posterior branches of the temporal artery. The main trunk of the temporal crosses the zygoma just in front of the ear, and is covered at this point by a layer of fascia derived from the parotid gland. It may be felt pulsating ½ to 1 cm. in front of the ear over the zygoma. Posteriorly, the posterior-auricular and the occipital arteries furnish the blood supply of the scalp. The occipital artery pierces the cranial attachment of the trapezius muscle and becomes superficial just behind the mastoid process —and on a level with the lobule of the ear, on a line joining the external occipital protuberance with the tip of the mastoid process. All these arteries anastomose very freely in and beneath the skin.

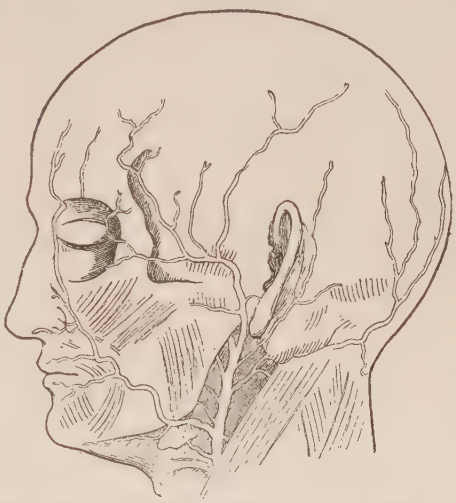


Fig. 134.—Diagram Illustrating the Arterial Supply of the Face and Scalp.

The *veins of the scalp*, in general, follow the course of the arteries. They communicate freely with the veins inside the skull. The frontal and supra-orbital veins, with the ophthalmic; the occipital, with the mastoid vein. The so-called emissary veins are also numerous. They pass through the skull in an oblique direction, and often communicate with the veins of the diploë. Some of them are small venous channels passing through the skull at or near the sagittal suture. These channels are known as parietal foramina; they afford communication between the superficial veins and the superior longitudinal sinus of the cranium. A vein also passes through the foramen cecum of the frontal bone; it unites the veins of the nasal fossæ with the superior longitudinal sinus. The posterior condyloid foramina transmit veins affording communication between the veins of the cranial cavity and the vertebral veins, as well as the deep veins of the back of the neck. In estimating the gravity of infectious processes of the scalp these venous channels of communication must be borne in mind.

Wounds of the scalp may be incised, contused and lacerated, punctured, or gunshot wounds.

Incised Wounds.—Incised wounds are those made by sharp-cutting instruments. They are linear and straight or curved in outline. If the cutting instrument strikes the head in a more or less tangential direction a considerable flap of soft parts may be raised from the skull or even completely cut away. Such wounds may be made by a saber stroke. Incised wounds dividing the skin merely, gape but little, though they bleed quite freely. Wounds which divide the galea gape notably. In the frontal and occipital regions transverse wounds gape more than those running antero-posteriorly. Bleeding from even a small wound of the scalp may be serious, or even fatal, if unchecked. The division of one of the larger arteries is readily recognized by the rapid escape of arterial blood in jets and by the anatomical site of the wound.

Contused and Lacerated Wounds of the Scalp.—Contused and lacerated wounds of the scalp are much more common as accidental wounds than clean cuts. They are caused by blows upon the head with blunt objects—clubs or stones and the like—or by falls upon the head against hard, rough, or angular bodies. They are sometimes produced by sudden violent traction upon the scalp—as when a woman's hair is caught in moving machinery. Explosions of gunpowder, dynamite, and gun-cotton produce extensive contused and lacerated wounds of the scalp. When the blow falls at right angles to the surface of the skull, the wound is often linear, and may, at the first glance, resemble an incised wound; close inspection will show contusion, fraying, and irregularity of the wound edges, or contusions and abrasions in the vicinity. Often the wound edges will be found infiltrated with blood, or pockets containing blood clot will be present. In some cases when a single blow has been struck by a sharp stone or a smooth club—and notably if it has fallen upon a bony ridge—the wounds may very closely resemble incised wounds, and the surgeon should exercise due caution if called upon to testify that a certain wound has been made by a sharp or by a blunt object, as the case may be.

When the force meets the skull obliquely, or nearly tangentially, the scalp may be extensively torn; thus, angular, rounded, or irregular flaps of scalp may be stripped up, and even completely separated from the head. Violent traction upon the hair by machinery may tear the entire scalp from the head. When a flap is created, the part of the wound where the violence was first applied will be contused, frayed, or completely crushed and shredded. The tears caused by stripping and traction upon the scalp are usually linear, and resemble clean cuts. The flaps usually include the skin and the galea, but if the pericranium was penetrated by the direct violence of the blow or fall, it may also be included more or less extensively in the flap.

Injuries to the Scalp caused by Explosions.—The injuries to the scalp caused by explosions are sometimes remarkable. I recall a case seen at Bellevue Hospital, when I was house surgeon there, of this character. A dynamite cartridge exploded among some workmen, who were thawing it out over a fire. Several of them were killed outright; one of them was brought living to the

hospital. Among his injuries was a wound which extended from ear to ear across the front of his face; a flap was thus created, including his upper eyelids, the upper half of his nose, and his forehead. This flap was raised and stripped back from his skull as far as his ears; the flap was everywhere filled with little stones and splinters of wood; many stones were embedded in his skull. His eyes were destroyed. Several hundred stones and splinters were removed from this dreadful wound and from his chest and arms. One wooden splinter, six inches long, entered his right forearm at its middle, and was removed from his upper arm near the shoulder. He survived, although blind and much disfigured.

Punctured Wounds of the Scalp.—Punctured wounds of the scalp occur for the most part as the result of stabs with knives, daggers, and the like; they may extend beneath the scalp for a considerable distance, and are often accompanied by injuries of the skull. A stab downward in the temporal region may pass to the inner side of the zygoma, and thus wound the deep temporal artery, giving rise to serious bleeding, and possibly rendering a ligature of the external carotid artery necessary.

Gunshot Wounds of the Scalp.—Wounds of the head made by rifle bullets and by shotguns fired at close range, or by portions of shell or other heavy projectiles fired in battle, are quite commonly immediately fatal, involving, as they often do, injuries to skull and brain of a destructive character. Wounds involving the scalp merely will usually have been made by revolvers of small caliber and low velocity, or by spent balls from rifles, or by small shot fired from a shotgun at a considerable distance. These wounds present three common types:

1. The bullet strikes the head squarely, but is of small size, is composed of soft lead driven at a low velocity, and flattens against the skull not far from the wound of entrance.

2. The bullet cuts a mere groove in the scalp, following more or less the contour of the skull for some distance.

3. The bullet enters the scalp and cuts a canal of considerable length between the galea and the skull, passing out again at a somewhat distant point, or lodging. In a wound of this last kind the bullet may be so deflected from its course by the skull, on the one hand, and by the dense aponeurosis on the other, that its path may partly encircle the head, so that the wound of exit may be nearly or quite opposite to the wound of entrance, creating an inference that the bullet has passed through the skull and the cranial cavity. The absence of a hole in the skull and of symptoms of injury to the brain will usually prevent this erroneous conclusion.

Bird-shot Wounds.—Wounds made by bird shot vary much in character, according to the range at which the shot was fired. If the range is short, and the load strikes the head or any portion of the body squarely, a large ragged hole is produced with great destruction of tissue. The distance at which such an injury will be produced depends upon the size and boring of the gun rather

than upon the size of the shot used, since—for a distance sometimes exceeding twenty feet—the effect produced by the shot traveling *en masse*, or but little separated, is that of a single large missile. For example, a man was accidentally shot in the loin by his companion. The gun was a twelve-gauge shotgun loaded with the usual charge of smokeless powder and an ounce and an eighth of No. 8 shot; the range is said to have been twenty feet. A large hole was torn in the loin behind, and a still larger hole at the point of exit in front, through which coils of torn intestine protruded. At greater ranges the wounds made by the pellets are discrete, and the penetration varies with the range and the size of the pellets. (See chapter on Gunshot Wounds.) Shotgun wounds of the head may be followed by fatal results, even when the range is considerable and the pellets small in size. For example, in a case reported by Dr. Lewis Stimson a single pellet of No. 7 shot entered a thin portion of the frontal bone just below the inner end of the eyebrow and produced a fatal injury of the brain.

Examination of Wounds in Diagnosis.—The examination of wounds for diagnostic purposes should be made with painstaking observance of the rules of asepsis. When it is remembered that the most trifling wound of this region may result fatally from erysipelas or intracranial suppuration, the weight of this caution becomes clear. Scrubbing and shaving the scalp over a considerable area should precede any exploration. Rubber gloves should be worn, and every possible effort should be made to avoid contamination, whether the wound be already infected or not. The important points to be remembered are: Does the wound divide merely the skin, or is the galea also divided? Is the pericranium separated from the skull? Is the skull itself injured? Is any important vessel divided or a nerve trunk? Is a foreign body present in the wound—a portion of the instrument which produced the wound, or hair, or dirt, or gravel, or a bullet, etc.? Are the edges of the wound contused to such an extent that their vitality is lost or imperiled? Is the wound infected, and to what extent?

Does the Wound Divide Merely the Skin, or is the Galea also Divided? Is the Pericranium Separated from the Skull? Is the Skull Itself Injured?—The depth and extent of incised and of contused and lacerated wounds is often apparent at the first glance after the wound has been wiped clean of blood, foreign material, or pus, as the case may be, and yet this is not always so. If the wound is small, it may be impossible to see whether the injury involves the skull or not. We then have recourse to the use of a sterile instrument, a probe, the handle of a scalpel, or the like, or a finger properly protected by a sterile glove. We may then at once discover by the presence or absence of a grating sensation transmitted to the hand whether the skull is exposed, and often whether the surface of the skull is smooth, or whether, on the other hand, an abrupt ridge is present, indicating a fracture. We may be misled in certain cases; when the pericranium is stripped up from the skull, the instrument may rise suddenly from the denuded bone upon the

stripped-up pericranium to a higher level, and thus the sensation of a slightly depressed fracture along the line of the stripped-up periosteum may be very distinct. If unable to decide positively, we enlarge the wound and verify the condition by direct vision.

Is Any Important Vessel Divided, or a Nerve Trunk?—Any considerable blood-vessel, if divided, will usually make itself evident, either at once, or during the cleansing operations, if the wound be recent. The main trunk and two principal branches of the deep temporal are so inaccessible that ligature of the external carotid is preferable to an attempt to ligate the wounded vessel itself. The division of the supra-orbital nerve, and its subsequent inclusion in a scar, may give rise to neuralgia.

Is a Foreign Body Present in the Wound?—Foreign bodies are to be searched for in contused and lacerated wounds, but more especially in punctured wounds—such as are caused by a stab with a penknife or the like. Such instruments are usually capable of infecting a wound, and if their presence is probable, careful search, enlarging the wound, if necessary, is desirable, not only for their extraction, but to exclude perforation of the skull. Gunshot wounds, on the other hand, do not necessarily demand search for, and extraction of, the bullet, if this is known to be lodged. In case the site of the bullet can be seen or felt through the skin, removal is proper; but indiscriminate probing is unwise and unnecessary. If the skin orifice is cleaned, these wounds often heal *per primam*. The site of any metallic foreign body embedded in the scalp can sometimes be appreciated by the use of the fluoroscope, and usually by means of a radiograph. (See the Use of X-rays in Surgical Diagnosis.)

To What Extent is the Vitality of the Wound Edges Imperiled?—The scalp is so abundantly supplied with blood that even flaps which appear to be much contused, and whose living connections are small, may still be expected to survive, either entirely or in part. Accordingly, too hasty a judgment should not be formed, since, under careful asepsis, nothing will be lost by waiting for actually dead tissue to distinguish itself from the living.

Is Infection Present in the Wound, and to What Extent?—While nearly every accidental wound of the scalp may be regarded as a possibly infected wound, and be treated accordingly, we now refer especially to wounds in which infection of one sort or another is already present. The scalp should be shaved over a large area surrounding the wound in order to make a proper examination. If infected, usually a boggy edematous condition of the scalp will be noted, and the size of this area is often a fair index of the extent of the infection. Redness of the skin is not marked unless erysipelas is present. The wound surface will be found covered with pale granulations or with sloughing tissue; the edges will often be slightly everted; a purulent exudate will usually be evident upon pressing the scalp near the wound; its absence does not preclude infection. If the wound has penetrated the galea the exudate is often confined beneath this layer, and exploration of the wound with an instrument or a gloved finger may be necessary to detect its presence. Should the

amount of purulent discharge seem excessive for the size of the wound, such an accumulation is probably present, and incisions in the scalp, often of large size, will be necessary to determine its extent and provide for proper drainage. If infection has extended beneath the pericranium, the pus will be found beneath this layer and bare bone will be seen and felt. If the skull itself is the seat of pyogenic infection, the bone will appear of a yellowish-green color.

If the infection is extensive, or of a severe type, constitutional symptoms will be present—headache, a rise of temperature, prostration, anorexia, and a leucocytosis of greater or less intensity. Inasmuch as the spread of purulent infection in the deeper layers of the scalp is often of an insidious character, and its results disastrous—including not only extensive necrosis of the galea, but also infection of the skull itself, and of the sinuses and meninges of the brain, leading to fatal pyemia or meningitis—no pains should be spared on the part of the surgeon to render his diagnosis complete at once; if necessary, by the administration of an anesthetic and exploration through proper incisions.

DISEASES OF THE SCALP

Erysipelas of the Scalp.—Wounds of the scalp appear to be peculiarly liable to erysipelatous infection. The region is one not commonly kept as clean as the rest of the person, and the hair harbors many bacteria very difficult to remove by ordinary means. The point of inoculation is in many instances a wound of the scalp itself, and, in perhaps a still larger number of cases, the disease begins in a wound of the face, the scalp becoming involved by the extension of the process. Ulcers upon the face or in the nasal fossæ, or suppurative processes in the antrum or frontal sinus, are not uncommon sites of infection. The infection may take place in a mere abrasion, or in a wound of any size during any stage of the healing process, or in a wound already infected with pyogenic microbes. If a clean granulating wound be present, the healing process may be but little affected by the new infection; or, on the other hand, the wound surface may become covered by a diphtheritic-looking membrane or become gangrenous. In a suppurating wound infected with erysipelas the amount of purulent exudate will often be notably diminished. Very often constitutional symptoms will precede the local signs some hours or a day. There will often be a sharp chill, followed by a rise of temperature, headache and prostration, a coated tongue. Discomfort in the stomach, and even vomiting, are not uncommon prodromal symptoms. Leucocytosis, with relative increase in the polymorpho-nuclear cells, is regularly present. When the local lesion appears, the affected portion of the scalp will be red, swollen, and edematous; the borders of the red area will be sharply circumscribed from the surrounding skin, but blisters usually do not form, as they do upon the face. The subjective symptoms of burning and itching are present.

In some severe cases of erysipelas of the scalp it is desirable that the entire

scalp should be shaved; in this manner alone can the progress of the disease be watched intelligently, and the complications recognized and met, if they occur. Subcutaneous abscesses—if such occur—can be noted at once and incised; and deep-seated so-called phlegmonous areas of suppuration and necrosis of the deep layers of the scalp are less likely to pass unrecognized in their early stages, as well as the dusky patches on the skin, which indicate perforation by the deeper-seated foci of suppuration.

The so-called *head symptoms*, accompanying erysipelas in this region, are often the cause of the gravest anxiety. Headache, delirium, and stupor, followed in bad cases by coma, are often observed. In some of the more severe cases these symptoms are marked, and yet the patients recover. It is not always possible in a given case to say during the progress of the disease whether the threatening symptoms are due merely to the severity of the constitutional poisoning, or to a septic thrombophlebitis of the sinuses of the brain, or to meningitis. The occurrence of vomiting, convulsions, of ocular, or other palsies, and later, of deep coma, point to an intracranial invasion. Erysipelatous infection of the tissues of the orbit is not infrequently complicated with invasion of the ophthalmic vein, and so of the sinuses of the skull. In the cases complicated by intracranial suppuration the avenue of infection may be through one or other set of emissary veins, or through the lymphatics, or along the sheaths of the cranial nerves. The intracranial process may consist of purulent thrombophlebitis of the venous sinuses, followed sometimes by pyemia; or of meningitis. (See Diseases of the Brain and its Adnexa.) The occurrence of furious delirium in the course of erysipelas of the scalp is not uncommon among chronic alcoholics.

Subcutaneous Abscesses of the Hairy Scalp.—The subcutaneous abscesses of the hairy scalp, whether occurring as a complication of erysipelas or from other causes, are to be recognized—as are similar lesions elsewhere—namely, by the formation of a painful, tender, red, circumscribed swelling, showing in its later stages the sign known as fluctuation, giving the sensation of elastic tension to the examining fingers. The deep-seated phlegmonous inflammations of the scalp, involving the galea or the pericranium, or both, are sometimes less easily recognized than superficial abscesses. Shaving the scalp facilitates the examination greatly. A boggy edematous condition of the scalp, often without redness of the skin, will be found upon examination. Tenderness may be marked, but in some of the more severe necrotic inflammations may be slight. Fluctuation may be present, obscure, or absent. The general symptoms are headache, a septic temperature, a rapid, and later a feeble pulse. Death may occur from the severity of the septic poisoning or from invasion of the interior of the cranium.

Upon incision the galea may be more or less completely necrotic, and the loose connective tissue beneath may be found infiltrated with pus, or a large cavity or a series of cavities filled with pus may exist beneath the aponeurosis. If unrelieved by incision, a large portion of the scalp may be lifted from the

skull, forming a loosely fluctuating sac filled with masses of necrotic tissue and pus. Gangrenous perforation or sloughing of the skin may occur at various points, and the pus may burrow deeply into the neck along the intermuscular planes or into the temporo-maxillary fossa. In some cases putrid decomposition of the tissues takes place, and infection with gasogenic bacteria will be accompanied by an emphysematous condition of the tissues, recognizable by a peculiar elastic consistence and by crepitation on palpation and by the escape of bubbles of gas mixed with thin purulent fluid when the incised tissues are compressed. (See Bacteria of Surgical Infections.) The course of the more severe types of these processes is sometimes terribly rapid, and death may occur very early, with the symptoms of profound intoxication—headache, delirium, stupor, coma, a feeble pulse, a high temperature, rapidly ending in collapse. The degree of leucocytosis will vary. If the tissues have time to react after the invasion of the bacteria, leucocytosis will often be marked, but in the most rapidly fatal cases this sign may be absent.

Malignant Pustule or Anthrax.—The malignant pustule or anthrax is not very common upon the hairy scalp. (See Anthrax.)

Eczema of the Scalp.—This disease occurs in an acute form upon the heads of neglected infants and young children. The dried exudate from the inflamed skin collects in thick crusts, cementing the hair into a firm mass over considerable areas. After the crusts are removed, the red, moist surface of the skin is scarcely to be confounded with other conditions. Before the skin can be properly exposed for observation and treatment, it is often necessary to soften the crusts with olive oil or the like, and to cut away the hair. In older children eczema of the scalp is often the result of the presence of pediculi. Continued scratching with infected finger nails gives rise first to an eczema, and later to pyogenic infection with the production of subcutaneous abscess behind the ears and along the border of the hair at the back of the neck. The recognition of the nits or ova of the pediculi attached to the shafts of the hairs is easy, and clears up the cause of the trouble at once. The ova are small ovoid-shaped bodies of a dirty white or brownish-white color attached to the shafts of the hairs by a cement furnished by the female louse. The lymphatic glands of the neck are often enlarged and tender, and sometimes suppurate. An interesting sign of the nervous irritation produced by these parasites is observed in many cases—namely, a typical torticollis or wry-neck, attended by tonic rigidity of one sternomastoid muscle. Removal of the parasites and of the eczema by cutting the hair, and appropriate local applications, is followed by speedy improvement and cure of the wry-neck.

Furuncles.—Furuncles do not ordinarily occur upon the hairy scalp, but a favorite location for them is upon the back of the neck at the junction of the hair with the naked skin. These infections of the hair follicles begin as a minute, tender, inflamed, red, swollen area in the skin, resembling an acne pustule. In the course of a few days the inflamed area is very red and hot. In the center of the conical swelling can usually be seen a yellow point cov-

ered by the thinned-out horny layer of the skin, representing the orifice of the affected hair follicle. If punctured, or allowed to rupture, several drops of pus escape, followed by a minute slough; a craterlike opening in the center is left in the skin with sloughy walls. Under appropriate surgical incision and disinfection the discomfort is speedily lessened and the disease shortened. The microbes concerned in the production of furuncles are usually Staphylococcus aureus and albus, and the same is true of carbuncle. The presence of numerous furuncles usually indicates a depressed state of general health. The patient should be carefully examined for causes of such depression. Such a cause may be diabetes, slow or imperfect convalescence from acute diseases (typhoid fever, for example), alcoholism, uncleanly habits, etc.

Carbuncle.—Carbuncle does not ordinarily occur upon the hairy scalp; the common site is the back of the neck, and the process often invades the scalp as high as the level of the ears. The disease may be regarded as a congeries of furuncles, but the necrotic inflammation extends into the subcutaneous tissues as deeply as the surface of the muscles, and in bad cases may involve the intermuscular planes. The recognition of carbuncle is easy. A painful, tender, hard, and brawny swelling, usually rounded or conical in contour, occupies the back of the neck. The size of the affected area varies; it may extend from ear to ear. The skin is at first red, later purple, and finally is perforated over small areas; here and there, through these apertures, pus and fragments of broken-down tissue escape. If untreated, the entire mass of necrotic skin and connective tissue may be cast off, leaving a deep, undermined, ragged cavity lined with sloughing connective tissue. Under less favorable conditions the disease may extend downward into the subcutaneous tissues of the back, and that without showing much evidence of its progress in the overlying skin. Carbuncle is a disease of depressed states of vitality. It is common in the course of diabetes, and is frequently the cause of death in this disease. Carbuncle is not uncommon during advanced life, and is rare in childhood. Debility from acute and chronic diseases and from the effects of bad food and exposure favor its occurrence. The pain of carbuncle is often severe, and in the early stages the inflamed skin is exquisitely tender. When the skin and subcutaneous tissues become necrotic the pain may subside. This is especially true in the diabetic and feeble, in whom the inflammatory reaction of the tissues is slight. I have known instances of this kind where the patient, his friends, and even his physician have been thus lulled into a perilously false sense of security, even when the profoundly septic patient was within a day or two of his death.

The *constitutional symptoms* of carbuncle vary in intensity with the extent of the lesion and the resisting powers of the patient. In the diabetic the symptoms are those of profound depression of all the vital functions. The fever is seldom high, but the pulse is rapid and feeble from the first. These patients are weak and prostrated, and the most powerful stimulating measures produce little or no effect. Operative removal of the infected tissues is sometimes

successful, but diabetic coma or death from septic absorption are the usual endings of these cases. Carbuncle affecting persons in otherwise fairly good condition rarely presents dangerous symptoms of constitutional poisoning provided operation is undertaken early. The fever and prostration are moderate, and a rapid return to a normal condition follows the removal of infected tissues.

FIG. 135.—TUBERCULOUS ABSCESS OF THE SCALP SECONDARY TO TUBERCULOSIS OF THE FRONTAL BONE. In this case there were numerous tuberculous foci in other parts of the body. (New York Hospital collection, service of Dr. Frank Hartley.)

Tuberculous Ulcers—Lupus.—Tuberculous ulcers of the scalp may occur secondary to tuberculous periostitis or osteitis of the cranial bones—notably from middle-ear and mastoid disease. Lupus of the scalp is rare except as an extension from the face. (See Lupus.)

Syphilitic Lesions of the Scalp.—*Chancre of the scalp* may occur from mediate contagion, but is exceedingly rare. *Secondary macules, papules, and pustules* are common on the scalp; they are commonly scaly, with the formation of crusts, and often itch. Along the border of the hair upon the forehead they constitute the "Corona veneris." *Syphilitic alopecia*—the falling of the hair—may be diffuse, most marked upon the crown, or in patches. It rarely, if ever, produces complete baldness. The *gummata of the scalp* form painless nodules in the skin—more rarely in the deeper soft parts—varying in size from a pea to a hen's egg. At first hard, then doughy, later semifluctuating. They grow rather slowly, and are finally absorbed or break down, forming typical punched-out ulcers, which may slowly spread superficially or involve the skull.

Ulcerating Epithelioma.—Ulcerating epithelioma occurs upon the scalp, usually as rodent ulcer. (See Tumors.)

Emphysema of the Scalp.—Emphysema of the scalp may occur as the result of fractures of bones of the face and skull which open into air-containing cavities—the frontal sinus, the nasal fossa, the ethmoid cells, the mastoid cells. The air usually accumulates between the galea and the pericranium in small

amount and over a limited area; a swelling is produced of elastic quality, which crackles on palpation. Inflammatory signs are absent.

Pneumatocele capitis.—As the result of congenital defects, or loss of substance through disease or injury, in the walls of the air-containing bony cavities of the skull and face—mastoid cells, frontal sinus, antrum of Highmore—accumulations of air may take place between the periosteum and the bone, with the formation of rounded elastic swellings, which diminish in size, or disappear on pressure, and grow larger from coughing, sneezing, or other sudden expiratory effort. Pneumatocele arising from defects in the mastoid process may be congenital or acquired, and may spread upward and backward, and in time involve a large area of the scalp. Those arising from the frontal sinus are usually due to disease of the bony wall of the sinus—syphilis or tuberculosis—or to injury. They form usually small, rounded, elastic tumors. The diagnosis of pneumatocele capitis is made from the presence of a soft elastic tumor, giving a resonant percussion note, painless, reducible, and without inflammatory symptoms. Sudden increase in size occurs when the patient makes an expiratory effort with the nose and mouth closed. The defect in the wall of the frontal sinus can sometimes be felt with the finger, in the mastoid process, less often.

Aneurisms of the Scalp.—The temporal artery and its branches and the occipital artery are the favorite sites of cirsoid aneurism—Angioma arteriale racemosum. The tumor consists of a congeries of dilated, tortuous arteries

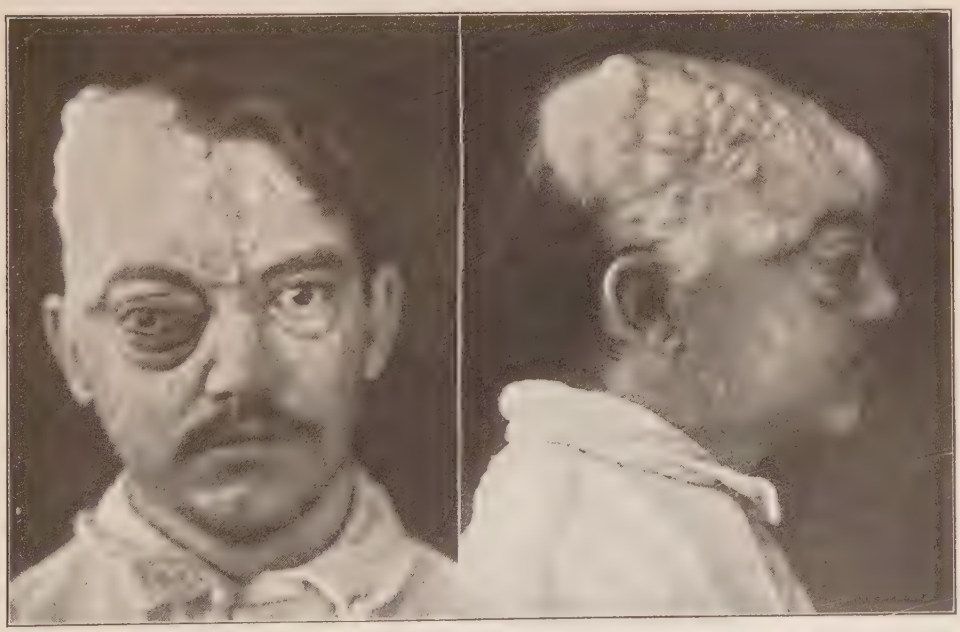


Fig. 136.—Cirsoid Aneurism of the Scalp and Skull. In this case the external carotid artery had been tied without any benefit. The tumor pulsated, was soft and compressible, and beneath the mass of dilated blood-vessels a depression or loss of substance could be felt in the skull. (The patient was under the care of Dr. L. W. Hotchkiss, through whose kindness the picture is reproduced.)

and veins with thickened walls, forming a moderately elevated mass upon the side of the head, usually above, and in front of the ear, and of variable size. The surface of the tumor is covered with normal or thinned skin. The outline and blue color of the individual vessels can be distinguished. The arteries leading to the tumor are dilated. The tumor is soft, pulsates, diminishes in size on pressure, and exhibits a soft, intermittent blowing murmur. Pressure upon the common carotid artery of that side *may* or may not cause the pulsation and murmur to cease, or diminish in intensity, and the tumor to diminish in size.

Arterio-venous Aneurism.—Arterio-venous aneurism may occur in the same situation from traumatism. It is to be distinguished from the above from the following characters: The history of injury, the presence of a thrill. The murmur is continuous. Pressure upon some point of the tumor itself causes cessation of pulsation, murmur, and thrill. The veins are especially dilated; the arteries leading to the tumor are normal. The growth is more rapid. Certain angiomata are hardly to be distinguished from cirsoid aneurism, except by absence of a murmur and pulsation, and the more usual presence of pigment in the skin over them, and the involvement of the skin capillaries, causing "port-wine stain." Sacculated or fusiform aneurisms of the temporal artery are occasionally observed as the result of trauma. The signs of aneurism are present.

TUMORS OF THE SCALP

Papillomata of the Scalp.—*Warts.*—Warts, both hard and soft, occur often upon the scalp. The pigmented hairy warts are sometimes the starting point of melano-sarcoma. Such warts are often tender and are readily wounded and caused to bleed by the repeated passage of the comb over them. *Horns* grow upon the forehead and scalp, sometimes from a wart, sometimes from a sebaceous cyst. They are yellowish-brown, brown, or almost black in color, and consist of stratified layers of horny epithelium. They may be the starting point of epithelioma. Horns may reach a length of several inches. They are attached to the skin, not to the bone.

FIG. 137.—UNUSUALLY LARGE SEBACEOUS CYSTS OF THE SCALP. (New York Hospital, Out-Patient Department, case of Dr. Hitzrot.)

Sebaceous Cyst—Atheromatous Cyst.—The scalp is the favorite seat of these tumors. They are

single or multiple, and form smooth, rounded, soft, or rather tense and elastic sessile or pedunculated tumors, varying in size from a pea to a hen's egg; adherent at one point to the skin. On pressure the characteristic sebaceous material can usually be expressed. They grow slowly and are painless, but may become infected, inflamed, and ulcerated. They are occasionally the starting point of horns and epithelioma.

Dermoid Cysts.—Dermoid cysts are of congenital origin. They are lined with a membrane containing histological elements of the skin; those upon

FIG. 138.—FIBRO-LIPO-LYMPHANGIOMA OF THE SCALP, NECK, AND SHOULDERS. This unusual case occurred in the service of Dr. Charles McBurney in the Roosevelt Hospital. The patient was operated upon a number of times and considerable portions of the growth were removed. The wounds always bled furiously and the character of the tissues was such that hemostasis was difficult.

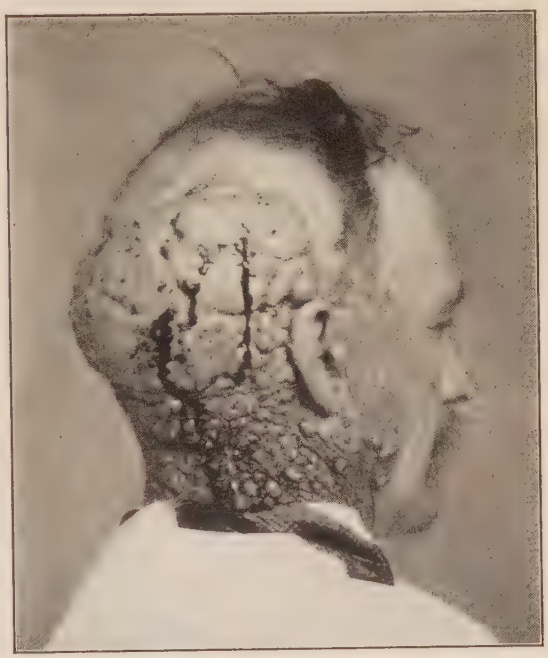


FIG. 139.—RESULT AFTER OPERATIONS UPON CASE SHOWN IN FIG. 138.

the scalp contain oily or fatty material, and sometimes hair. Their favorite situations are the outer angle of the orbit, the root of the nose, the temporal region, behind the ear, and in the situation of the large fontanelle. Dermoids bear a superficial resemblance to sebaceous cysts, but have a deeper origin and are adherent to the periosteum or bone. Sometimes they sit in a bony depression in the skull; occasionally there may be a hole in the skull beneath them, and through this they may extend into the cranial cavity; such dermoids may pulsate. Dermoids grow slowly, and may not be observed until puberty. The diagnosis is to be made from the situation of the tumor, its deep attachment to the bone and immobility, its rounded shape and elastic consistence. A differential diagnosis between dermoid and congenital hernial protrusion of the brain or its membranes is usually possible. The hernial

protrusions are situated over a suture; they are reducible or diminish in size on pressure and during sleep; they pulsate and are increased in size by sneezing, coughing, etc.

Carcinoma of the Scalp.—Carcinoma of the scalp occurs in two forms—the chronic, superficial, ulcerating, less malignant form, known as *rodent ulcer*, and the infiltrating epithelioma which invades the deeper tissues, and early infects the lymph glands and causes general carcinosis. The favorite situations are the forehead and the temporal region. Chronic irritations and inflammations of the skin, warts, and scars, and, as already stated, sebaceous cysts in the aged, are the common starting points of epitheliomata. (See Tumors.)

FIG. 140.—ANGIOMA OF THE SCALP, WHICH AS THE RESULT OF INJURY, BLED PROFUSELY. The tumor was probably an angio-sarcoma. (New York Hospital collection, service of Dr. Murray.)

Fibroma.—The hard fibromata rarely occur upon the scalp. Soft fibroma (Fibroma molluscum) is common, and may occur in any situation, in any number, and of any size. When large, they form soft pendulous tumors, which are quite vascular, and often produce extraordinary deformities. (See Fibroma.)

Keloid.—Keloid is not infrequent upon the scalp as the result of scars, and is very common upon the lobule of the ear in negro women as the result of boring the ear for earrings.

Neurofibromata—Plexiform Neuroma.—Plexiform neuroma has been observed upon the forehead, in the temporal region, behind the ear, and in other situations. They are often pigmented and hairy growths, sometimes tender and painful, of soft, rather uneven consistence. They form flaccid tumors which may give the sensation of a bundle of worms beneath the skin upon palpation. They are often combined with hypertrophy of the skin and subcutaneous tissues.

Angiomata. (See Cirsoid Aneurism.)

Nevus vasculosus—Angioma simplex.—Nevus occurs upon the forehead and scalp as a congenital tumor, consisting of dilated capillaries and small blood-vessels; it is often pigmented and hairy, varies in size from the fraction of an inch in diameter to the size of a hand or larger. Their peculiar pink-red to deep-red or purple color renders their diagnosis simple. They are

often combined with lymphangiomata, and are then pale in color. The *cavernous angioma*, which consists chiefly of dilated vessels and spaces in which the distinction between arteries and veins is more or less lost, occur upon the scalp. In structure they resemble the tissue of the corpus cavernosum penis. They form soft compressible tumors, usually congenital, sometimes pigmented, rarely pulsating.

Blood Cysts.—Under this title are described cyst formations, containing venous blood, which occur upon the scalp and communicate with the veins of the interior of the cranium. Such blood cysts are situated beneath the pericranium, and communicate by an emissary vein with the longitudinal sinus. They may pulsate.

Fig. 141.—Abscess of the Scalp behind the Ear, Simulating Mastoiditis.

Lipoma.—Lipoma is a rare tumor upon the scalp; when it does occur, it is most often situated upon the forehead and beneath the aponeurosis of the occipito-frontalis or the temporal muscle. They form rounded or flattened elevations, and upon palpation are soft and elastic. At the borders of the tumor there is sometimes a thickened layer of periosteum, such that, upon palpation, the tumor may feel as though it sat in a depression in the skull. Very rarely large lipomata have been observed in the scalp, and one case is reported of a negro woman who had such a tumor of enormous size. It hung down as far as her knees. In lipomata of the scalp the lobulated character of ordinary lipomata is usually wanting; the surface of the tumor is smooth; they are but slightly movable. The differentiation from dermoids depends upon the localization of the latter, and the fact that dermoid appears early in life—often in infancy—while lipoma usually grows in later years.

Enchondroma and Osteoma.—Enchondroma and osteoma have very rarely been observed in the soft parts of the scalp.

Endotheliomata.—Endotheliomata occur upon the head in two forms. The first, *cholesteatoma*, so-called "mother-of-pearl" tumor, may appear in the scalp as an outgrowth from the cranial bones, often from the temporal bone; they are sometimes mistaken for sebaceous cysts or dermoids. Second, the *malignant endothelioma*, or angiosarcomata, usually originate in the cranial bones or from the membranes of the brain. In gross appearance and mode of growth they are hardly to be distinguished from carcinoma. They are sometimes very rich in blood-vessels, and may pulsate and a murmur may be present.

Sarcoma.—The various forms of sarcoma originate in the scalp, in the cranial bones, or in the membranes of the brain; they do not differ in character from sarcomata elsewhere. (See Sarcoma.)

CHAPTER XIII

INJURIES AND DISEASES OF THE SKULL

DIAGNOSIS OF INJURIES OF THE SKULL

In considering the diagnosis of injuries of the skull we have to remember that two entirely distinct sets of signs and symptoms may follow traumatisms of the head. First, those due to the injury of the bone and the overlying soft parts, and second, of far greater consequence, the signs and symptoms due to injury of the cranial contents, the brain and its membranes, the blood-vessels, and the cranial nerves. The injuries of the bones of the skull are relatively unimportant, except in so far as they have a bearing upon the immediate or remote effects produced upon the cranial contents. In discussing the diagnosis of fractures of the skull I have followed Stimson's classification, namely: circumscribed fractures of the vault; fissured fractures with generalized brain injury; other forms.

Circumscribed Fractures of the Vault.— Circumscribed fractures of the vault are produced by direct violence acting over a limited area, causing a fracture at the point at which the violence is applied. They may or may not be accompanied by injury of the cranial contents; such injury, if present, is distinctly localized. The fractures may be of various types: Fissures, cuts which shave off a portion of the skull; fractures of the inner or outer table alone, comminuted, with depression; perforations. Many of these fractures are compound, some are simple.

Fissures.—Fissures may be produced by blows, as with a hammer, or by cuts of a saber or any sharp-edged instrument. The fissure may extend partly or entirely through the skull; may be as long as the portion of the instrument which struck the skull, or longer. A tangential or oblique cut may wholly or partly shave off a fragment, including the outer table merely, or the entire thickness of the skull. These fractures are always compound and are open to direct inspection; they offer no difficulties of diagnosis except that a torn edge of periosteum may cause a sensation to the examining finger which exactly resembles that produced by the edge of a fissured fracture. The diagnosis should be corrected by the eye. A suture in the skull may resemble a fissured fracture. A fracture usually bleeds, or may be made to bleed, by scraping it with a piece of gauze or an instrument.

Fissured fractures of limited extent may also be produced by blunt objects

which affect the skull over a limited area; such fissures, if simple, will give rise to no definite signs of fracture other than pain when the line of fracture is pressed upon with the finger. A similar kind of violence may rarely produce bending of the outer table of the skull, and fracture of the inner table alone. Such injuries are rare, and will not usually be discovered unless they are fatal from wound infection, or, as in one reported case from intracranial hemorrhage. Fracture of the external table alone may result when a bullet passes through the skull from one side to the other and strikes the internal table, bending it outward, and causes a scale of bone to be separated from the external table without perforating. Such injuries are extremely rare, and would not usually be discovered on account of the overshadowing importance of the injury of the brain.

Depressed Fractures of the Skull.—Depressed fractures are usually compound and comminuted on account of the method of their production by blows from small, hard objects—clubs, stones, hammers, and the like. If compound, the diagnosis is usually easy, the depressed fragment, or fragments, can be seen or felt in the open wound. If the depressed portion of bone remains attached at some part it will tend to spring back into place, and in doing so frequently catches and holds some hair. The fracture of the inner table is always more extensive than that of the outer. In other cases the fracture will circumscribe a more or less rounded portion of the skull, the depressed portion is usually comminuted, it may be depressed *en masse*, or the depression may slope toward the center; again the internal table will be more extensively fractured. From the edges of the depression one or more fissures may be found, either long or short, and running away from the depressed area.

Fig. 142.—Simple Depressed Fracture of the Skull without Symptoms. (St. Mary's Hospital, service of Dr. Charles N. Dowd.)

If simple, the seat of the depression can usually be readily detected with the finger through the scalp. A fallacy, however, may arise, as already spoken of under contusions of the scalp, if the fracture is a day or two old. A hematoma may be present in the case of a contusion without fracture, and a ring of fibrin may be deposited around its border; the examining finger feels this ring of fibrin, and passing beyond it seems to sink into a depression in the

skull. The fibrin may be displaced by rubbing and pressure, when the apparent depression disappears. In case of depressed fractures, elevation and removal of depressed fragments may show laceration of the dura, hemorrhage from the dura, from one of the sinuses, or from an artery, or laceration of

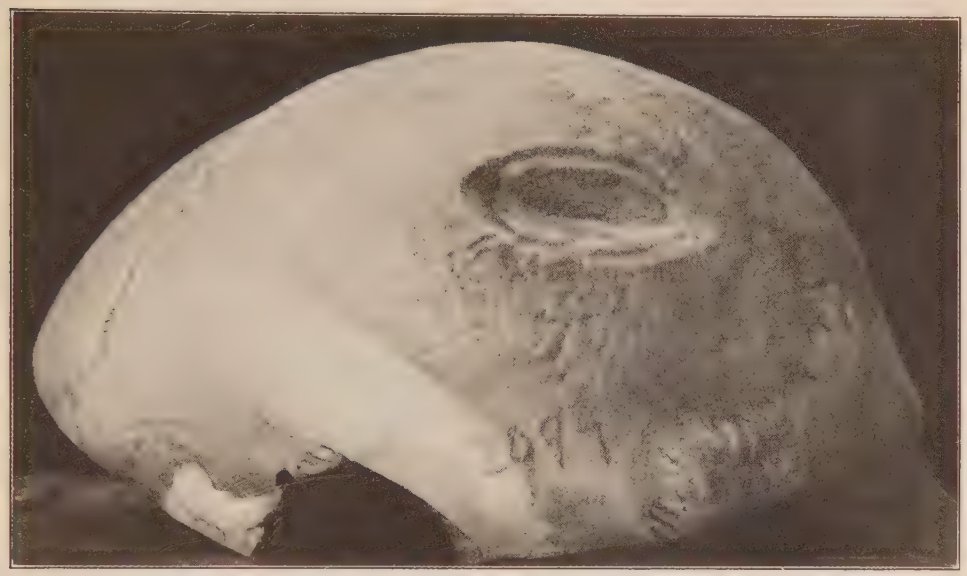


Fig. 143.—Depressed Fracture of the Skull. (Museum of the New York Hospital.)

the brain, or hemorrhage from the vessels of the pia. A portion of the internal table may be driven into the brain, or a bullet or other foreign body may be discovered. There may be the escape of brain tissue, occasionally a flow of cerebro-spinal fluid.

Depressed fractures of the skull may be accompanied by the symptoms of concussion or compression of the brain, and may give rise to general and local symptoms. The symptoms of concussion of the brain or cerebral shock are immediate. Partial or complete unconsciousness following the injury, and lasting for a variable time—from a few moments to a few hours—the recovery is rapid or gradual. Vomiting sometimes occurs, and headache. Other symptoms of shock may be present, a rapid and feeble pulse, paleness, and coldness of the surface, together with shallow, slow, or irregular breathing. During the period of the recovery the patients may be excited and irritable. Additional symptoms to these usually indicate contusion or laceration of the brain, or cranial nerves, or cerebral compression from intracranial hemorrhage. Depressed fractures of the skull when they are over some portion of the motor area, and are accompanied by paralysis of certain groups of muscles, indicate that the function of the compressed portion of brain is interfered with, and call for operation. If the symptoms arise at once, the indication is clear; if not for several days, it may be that the symptoms are due to the spread of an inflam-

matory process having its origin at a point some distance away from that portion of the brain which is giving rise to the symptoms.

Complications.—*Hemorrhage from the Middle Meningeal Artery.*—A very important complication of fracture of the vault of the skull, and one which may occur after injuries of the head without fracture, is hemorrhage from the middle meningeal artery or one of its branches. The middle meningeal artery enters the cranium through the foramen spinosum, and runs between the dura and the skull, in a groove in the latter, outward, then upward. The artery divides into an anterior and posterior branch. The anterior branch passes upward and forward in the direction of the forehead. The posterior branch passes horizontally backward. The anterior branch is more commonly ruptured in fracture, the posterior branch less often. In cases of compound fracture of the skull in which the artery bleeds externally, the situation of the hemorrhage may serve as a guide to the injured vessel. In case the point of injury cannot be exactly localized, the anterior branch may be exposed by a trephine opening or an osteoplastic flap—in the adult, two fingers' breadth above the zygoma and one inch behind the external angular process of the frontal bone. The main trunk of the artery as it leaves the great wing of the sphenoid crosses the anterior inferior angle of the parietal bone. The posterior branch may be exposed by an opening three inches posterior to the first. In practice, the same osteoplastic flap may include both branches. (See also Cerebral Localization.)

The symptoms of hemorrhage from the artery may come on at once, or be delayed for several hours, or even days. They will vary somewhat according to the rapidity of the bleeding and the amount and situation of the hematoma. Usually the patient has few or no symptoms immediately after the accident. The symptoms produced consist of localized paralyses, and of general symptoms of compression of the brain. In some cases the symptoms of concussion following the injury will gradually merge into those of compression. The headache, irritability, nausea, and vomiting are followed by lethargy, stupor, and coma. Paralyses due to compression of the cortical motor area are localized to one limb or set of muscles or are more extensive (hemiplegia). In the former case the hemorrhage is probably between the dura and the skull; in the latter, beneath the dura. The paralyses occur upon the side of the body opposite to the injury. The pulse becomes slow (the pulse of compression of the brain). The pupils of the eyes are of unequal size; the pupil is often larger upon the injured side.

Gunshot Fractures of the Skull.—Gunshot fractures of the skull have been spoken of under Gunshot Wounds; as there pointed out, they vary in gravity from mere contusion of bone, or the production of a superficial furrow in the outer table, to complete or extensive disorganization of the calvarium. Pistol bullets of small size, and fired at low velocity, may flatten against the skull without seriously injuring the bone, or may produce a perforation corresponding in size to the caliber of the bullet, without much splintering, and enter the brain, producing serious or immediate fatal symptoms from destruc-

tion of important centers in the brain or medulla; or, on the other hand, they may remain and produce no symptoms whatever, or be accompanied by immediate infection and abscess of the brain or purulent meningitis; or may produce little or no reaction at the time, and after an indefinite period cause abscess or meningitis, or both, with fatal results.

Extraordinary contrasts are sometimes presented by these cases. A patient of mine fired three shots from a .22 caliber pistol upward into his open mouth. He was brought to the hospital unconscious, and with the symptoms of compression of the brain. The unconsciousness persisted for three days, and was then slowly recovered from. There was exophthalmos of the left eye, with dilatation of the pupil and blindness in that eye. In the course of two months all the signs and symptoms passed away, except that vision in the left eye was slightly impaired. A series of X-ray pictures located two of the bullets in the brain in the anterior fossa of the skull. Stimson relates a case in which a single No. 7 bird shot entered just above the tendo-oculi, and passed through the lower part of the frontal lobe, directly back nearly to the Sylvian fissure, and caused death in a week without any evidence of inflammation, and with only a minute intracranial hemorrhage.

Fractures of the skull by rifle bullets of large caliber, and by high-powered rifles firing small-calibered bullets at high velocities, produce, as already pointed out under Gunshot Wounds, extensive destruction of the skull and brain. The wound of entrance in the scalp usually corresponds with the size of the bullet. The wound of exit is usually larger, and is accompanied by extensive comminution of the skull. Such injuries are fatal at once, or within a few hours. When fired at distances less than 800 meters, extensive comminution and fissures surround the wound of entrance and of exit in the skull. Beyond that range the splintering and comminution of the skull and the disorganization of the brain diminish, and at extreme ranges—2,500–3,000 meters—simple perforations are observed without explosive effect. When fired at long range, however, small-calibered rifle bullets may occasionally lodge and remain in the brain without producing symptoms, or the symptoms, though present, are distinctly localized. The fractures of the base of the skull through the mouth, the nose, or through the orbit, in the form of small perforations, whether produced by bullets or by pointed objects—daggers, sticks, umbrella handles, etc.—are dangerous and often fatal injuries, on account of the unavoidable and frequent infection as well as from injury of brain tissue and hemorrhage.

Fissured Fractures with Generalized Brain Injury.—These are the fractures produced by blunt violence such as falls upon the head, crushing injuries, falls upon the buttocks, feet, or knees from a height. The mechanism is that the skull is compressed in one direction and forced to expand in another beyond the limits of its elasticity, producing the so-called bursting and bending fractures, accompanied by general contusion and laceration of the brain, with hemorrhages from the vessels of the dura and pia, or of the brain substance itself, and from the larger or smaller arteries passing through the base of the skull

or the venous sinuses; injuries of the cranial nerves by hemorrhages into their sheaths, less commonly by their rupture. For the mechanism of these fractures I am compelled, for want of space, to refer the reader to systematic works on General Surgery and on Fractures. It may be sufficient here to say that these injuries commonly cause fissured fractures, extending through the base of the skull in various directions. That the fissures are frequently prolonged toward the vertex, and even circumscribe the entire skull, so that it is broken into two portions, movable one upon the other. The lines of fracture most commonly cross the middle fossa of the skull, usually in a more or less transverse direction, fracture the petrous portion of the temporal bone near its anterior border, and open into the middle ear. Sometimes they pass into the anterior fossa, and sometimes into the posterior fossa.

There are, further, fractures of the vault produced by great degrees of violence, such that extensive simple or compound comminuted fractures of the vault occur, with or without fissures, which may or may not extend to the base, and accompanied by serious generalized injuries of the brain. The importance of both these groups of fractures, from a diagnostic point of view, depends but little upon the injury to the skull, but upon the associated injuries to the intracranial contents.

Symptoms.—The symptoms of these fractures are those of serious general injury to the brain. There is unconsciousness, more or less complete, irregularity of the pupils of the eyes, paralyses of greater or less extent, which vary according to the seat of the injury to the brain or to the cranial nerves—to be spoken of later. There is a rise of temperature, usually moderate but which may become very high just before death. The pulse is sometimes increased in frequency, and sometimes it is slower than usual. Respiration may be affected in various ways, according to the portion of the brain injured. The signs and symptoms referable to the fracture are hemorrhages from the ears, the nose, or the mouth—the hemorrhage may be slight or profuse—the escape of cerebro-spinal fluid from the ear, from the nose, and occasionally through the Eustachian tube into the throat; sometimes the escape of brain tissue through the same channels. In fracture of the base through the middle fossa of the skull, involving the petrous portion of the temporal bone, there is deafness in the ear on the injured side. It is to be remembered that hemorrhage from the ear may be caused by rupture of the *membrana tympani*, or fracture of the anterior wall of the external auditory canal, caused by a blow upon the chin, transmitted through the condyles of the jaw to the temporal bone. The discharge of blood from the ear, from the nose, and into the throat do not constitute certain signs of fracture of the base.

The escape of cerebro-spinal fluid from the ear may be noted at once, or, more commonly, the discharge is first bloody, later a mixture of blood and cerebro-spinal fluid. At the end of a day or more the fluid may be entirely clear. If the tympanic membrane remains intact and cerebro-spinal fluid escapes from the ear, it indicates a fracture of the superior wall of the external

auditory canal. If the tympanic membrane is not ruptured, the fluid may find its way through the Eustachian tube, and into the throat or through the nose. In fractures extending into the anterior fossa, also, cerebro-spinal fluid may flow into the nose. The quantity of cerebro-spinal fluid discharged varies. It is usually greatest from the ear. It may amount to several ounces, or to as much as a pint, in twenty-four hours. The fluid is alkaline in reaction, contains a considerable quantity of sodium chlorid, and very little albumen. A copious discharge of lymph may take place from the ear, containing a large quantity of albumen. Such lymph may be derived from the lymph space of Schwalbe in the labyrinth. Two other varieties of discharge may be noted. "The flow is abundant and albuminous, becoming scanty and purulent; probably an inflammatory discharge from the surface of the cavity of the tympanum. Or the flow is scanty, appears later, is albuminous and reddish, and is probably the serum of extravasated blood." (Stimson, "Fractures and Dislocations.")

The escape of brain substance from the ear or from the nose is, of course, a certain sign of fracture of the base, with laceration of the membranes of the brain, and of the brain itself. There are frequently ecchymoses. The most common situation is beneath the conjunctiva, spreading to the eyelids. It is especially marked in fractures of the orbital plate of the frontal bone. Similar ecchymosis may be observed in the skin behind the ear; it usually appears a few days after the injury; also in the mucous membrane of the throat. When an extensive hemorrhage takes place into the orbit there may be exophthalmos.

Fractures through the mastoid cells, or the frontal sinus, or the ethmoid cells, may be accompanied by moderate subcutaneous emphysema. The paralytic symptoms depend partly upon contusion and laceration of the brain, or upon intracranial hemorrhage, or upon laceration of or pressure upon the cranial nerves. Paralysis of the extremities is more commonly due to intracranial hemorrhage and pressure upon the motor area than upon laceration of the brain. A slow pulse usually indicates pressure upon or hemorrhage into the medulla, and the same is usually true of disturbances of respiration. Injury of or pressure upon centers in the brain itself is attended by paralysis upon the opposite side of the body. Injuries of the cranial nerves by paralysis upon the same side of the body. They may be due to rupture of the trunk of the nerve—usually when the line of fracture crosses its foramen—or to pressure, or to hemorrhage into the sheath of the nerve. The facial nerve is more often injured than others. Next in frequency the abducens.

The most striking symptom of fracture of the base of the skull is more or less complete coma. This must be *differentiated* from alcoholic and uremic coma, and from apoplexy and opium poisoning. The history of an injury to the head is important. Alcoholic coma is rarely as profound as that due to injury of the brain. The odor of alcohol upon the breath is a sign which has landed many an individual with fracture of the base of the skull or apoplexy in the police station. The pupils are equal in the coma from alcohol. If the patient be sharply slapped upon the face, the pupils of the eyes will usually rapidly

dilate and then contract again. There is no paralysis. The coma of apoplexy is complete. The breathing is stertorous, the pulse is usually slow. There is hemiplegia or paraplegia. In opium poisoning the pupils are contracted to pin-point size, and remain so. The patient can sometimes be momentarily roused; there is no paralysis. In uremic coma there will be evidences of nephritis, sometimes edema of the extremities; urine withdrawn through a catheter will be albuminous, and contain casts; there are sometimes general convulsions; there is no paralysis. An examination of the fundus of the eye with an ophthalmoscope may show evidences of degeneration of the retina, and other signs common in nephritis.

DISEASES OF THE SKULL

Acute Inflammation of the Periosteum of the Skull (*Pericranitis acuta*).—Acute purulent inflammation of the pericranium occurs as the result of infected wounds of the overlying soft parts, or as an extension of inflammatory processes of the soft parts or of the bone, as abscess of the scalp, erysipelas, disease of the middle ear or mastoid process, and as a complication of infected fractures or of acute osteomyelitis of the cranial bones. In the most acute cases the disease may be ushered in by a chill, a rapid elevation of temperature, and all the symptoms of acute sepsis. Locally the patient will complain of headache; the scalp will be swollen and edematous and doughy, but may be normal in color if the inflammation is primary in the periosteum. The swollen area will be tender on pressure, and beneath the scalp there will be, at first, an indurated swelling connected with the bone, over which the scalp may be movable. Later there will be deep fluctuation; the swelling and edema may extend into the neck or the face. Frequently the disease is secondary to phlegmonous inflammations of the scalp. The constitutional symptoms are often grave.

Acute Inflammation of the Cranial Bones—Acute Osteomyelitis.—Acute osteomyelitis occurs as the result of infected wounds of the soft parts, of infected fractures of the skull, and of phlegmonous and other inflammations of the scalp. The disease is usually associated with inflammation of the pericranium and of the dura. Only in isolated cases has it been observed confined to the spongy tissue of the diploë. The bone appears of a yellow color instead of its normal pinkish-white. The condition is scarcely to be regarded as a diagnostic entity, and is usually a portion of the pathological process in acute purulent infection of the dura and pia, and of sinus thrombosis and pyemia following infected fractures and wounds of the skull, and sometimes accompanying mastoid disease. The signs and symptoms, therefore, are rather those of inflammation of the membranes of the brain, etc., than of the inflammation of the bone itself, and will be discussed under these topics. The chronic inflammations of the bones of the skull are chiefly tubercular and syphilitic.

Tubercular Inflammation of the Skull.—Tubercular inflammation of the skull may be primary or secondary to tubercular disease of the soft parts of the face

(lupus) or of the scalp, or most frequently of the middle ear. Primary tubercular disease of the skull occurs most frequently on the forehead and the parietal region. In young persons, usually only in those who have other tubercular foci. The signs and symptoms are a slowly developed, tender, painful, circumscribed, doughy swelling, which later fluctuates; incision evacuates tuberculous pus and reveals a more or less extensive area of tubercular caries of the underlying bone; sometimes absorption of bone and loss of substance, extending through the thickness of the skull. The lesion has the characteristic appearances of tuberculosis. Tubercular meningitis or general tuberculosis are not uncommon complications. The secondary tubercular inflammations of the skull occur most often as the result of tuberculous inflammation of the middle ear and of tuberculous ulcerations of the nasal mucous membrane. The diagnosis must be made from the situation, the character of the discharge, the recognition of tubercle bacilli, the chronic course, and the presence of tuberculosis elsewhere.

Syphilis of the Cranial Bones.—Syphilis of the cranial bones occurs in the form of circumscribed or diffuse periostitis, or of gummata. *Syphilitic periostitis* is common in the form of the so-called *syphilitic nodes* on the frontal and parietal bone. They occur in the later stages of the disease, and form firm or elastic, rounded, moderately elevated, tender swellings, single or multiple, of varying size from a fraction of an inch to an inch or more in diameter. They run a chronic course, lasting for months, sometimes for years. They may disappear under treatment, leaving the bone intact or pitted, or break down and ulcerate, leaving characteristic punched-out ulcers. They may cause syphilitic caries or necrosis, with loss of substance, and leave extensive defects in the skull. The condition is exceedingly chronic, and the process may extend over years.

Gummatous periostitis may also be diffuse, and cover in time the greater part of the vault of the skull. The process tends to advance slowly. The lesions are often multiple gummy nodules, which coalesce. Breaking down and ulceration are common. Destruction of bone may be superficial, leaving behind a peculiar and characteristic worm-eaten appearance of the surface of the skull, or deep-seated, causing caries or necrosis of the entire thickness of the skull, with extensive perforations and loss of substance. Characteristic of the process, also, is the production of new bone, nodular or diffuse thickenings of the skull, syphilitic hyperostoses. The destructive and productive processes may proceed side by side. When the soft parts soften and break down, extensive ulcers form. The necrotic bone surfaces are exposed. Putrefactive changes take place. The bone turns green or black; the discharge of pus is often profuse, and has a stinking and horribly offensive odor. Gummata also occur in the spongy tissue of the diploë, and upon the surface of the inner table of the skull. They also may lead to caries, necrosis, and the production of new bone, and are frequently complicated by inflammations of the dura (pachymeningitis syphilitica gummosa); severe continuous headache is a characteristic symptom.

Necrosis of the Skull.— Necrosis of the skull follows infected fractures or wounds and osteomyelitis of the cranial bones and necrotic inflammations of the overlying soft parts, with extensive destruction of the pericranium. It is rare as the result of aseptic operations. The necrosis may be superficial, or involve the entire thickness of the skull. No involucrum is formed. The dead bone separates slowly, and loss of substance is replaced usually by fibrous scar tissue merely, rarely by bone.

Imperfect Ossification and Atrophy of the Skull.—Imperfect ossification of the skull may occur as a congenital condition thought to be due to congenital rachitis or syphilis. The vault of the skull may consist of numerous small bony plates, with soft places between and abnormally large fontanelles. Localized atrophy may occur from the pressure of tumors—notably dermoids—or from aneurisms. Atrophy occurring after birth in children is usually due to rachitis (craniotabes rachitica). The softening of the bone is most marked in the occipital region, and may reach a grade such that the skull can be impressed with the fingers. The symptoms of cerebral compression or convulsions may occur in such cases. A similar condition has been observed in adult women suffering from osteomalacia.

Fig. 144.—Diffuse Hypertrophy of the Skull. (New York Hospital Museum.)

Hypertrophy.—Diffuse and circumscribed hypertrophies of the skull may occur both on its outer and inner surface. In the diffuse form all the bones of the skull and face may become greatly thickened (leontiasis ossium). The

circumscribed hypertrophies in the interior of the skull may gradually cause cerebral compression and death from atrophy of the brain.

Aneurism of the Arteries of the Skull.—Aneurism of the arteries of the skull may be single or multiple; they produce at first bony swellings upon the skull; later the bone is thinned, and crackles on compression; finally, the bony covering is absorbed, and a soft, pulsating tumor appears, giving the signs of aneurism. Rupture, externally or into the cranial cavity, causes death from hemorrhage or cerebral compression. A few cases of aneurism of the middle meningeal artery have been reported.

Tumors of the Cranial Bones.—Enchondromata may originate in the ethmoid bone and grow into the frontal sinus, the nasal fossæ, or the orbit; they usually become converted into bony tumors, and cause symptoms mechanically—displacement of the eyeball, stoppage of the nasal fossæ, etc. They are to be recognized by their stony hardness. Bony tumors may grow from the outer or inner surface of the skull or from the diploë. They are usually sessile tumors, are of slow growth, and smooth or uneven surface and hard consistence. On the outer surface of the skull the history and physical characters of the tumor, or an X-ray picture, establish the diagnosis. In the interior of the skull they may reach a considerable size and yet produce no cerebral symptoms; occasionally they may impair, by pressure or stretching, the functions of one or more of the cranial nerves. A mistake in diagnosis is possible between an osteoma and a central sarcoma of bone before it has caused complete absorption of its bony covering. An X-ray picture will show whether the tumor consists of bone or soft tissues. I saw a case of osteoma of both orbits and double exophthalmos when I was interne in Bellevue Hospital; there were no subjective symptoms.

Sarcoma.—Any of the forms of sarcoma may occur in the skull. They originate in the periosteum, from the bone itself or from the dura. Here, as elsewhere, they are apt to be rapidly growing tumors, and in the skull destroy life, after a variable period, from hemorrhages, from interference with the functions of the brain, meningitis, sepsis. They all tend to penetrate the skull inwardly or outwardly, according to their original site. Those which grow from the pericranium form tumors of softer or harder consistence, according to their type; they may reach a large size before producing much general or local disturbance. Ulceration, sloughing, and dangerous bleeding are apt to occur sooner or later, and the skull is sometimes penetrated and the dura and brain involved quite early in the disease in spite of the absence of symptoms. Those which originate in the bone remain covered by a thin bony envelope for some time, and may set up such an irritation that considerable new bone is produced in the form of osteophytes. The bony covering is finally perforated, and a loss of substance can be felt, through which the tumor continues to grow.

The sarcomata arising from the dura may simply infiltrate the skull, and thus infect the overlying soft parts, or they cause absorption and perforation

of the skull; after such perforation they may receive transmitted pulsation from the brain; later, as the tumor grows and spreads in the tissues of the scalp, the pulsation is no longer felt. Secondary tumors in the head and elsewhere may occur if the patient survives for a sufficient time. The sarcomata of the dura afford the worst possible prognosis, those from the bone almost as bad; those from the pericranium may occasionally be cured by operation. It is not always easy, nor even possible, to determine whether a sarcoma has originated in the bone or from the interior of the skull. Soon after a sarcoma of the dura has perforated the skull it may pulsate and be partly reducible, which points to an intracranial origin. As the tumor grows these signs are apt to be obscured. The differential diagnosis between aneurism and pulsating sarcoma has already been referred to under the head of Aneurism. It should be remembered that absence of cerebral symptoms does not necessarily indicate that the tumor has not invaded the interior of the skull. In the perforations from without, the dura may long remain intact and the brain be gradually pushed away by the growth of the tumor without producing cerebral symptoms. The favorite sites for sarcoma of the skull are the parietal and frontal regions. They may also develop from the base of the skull and elsewhere. I operated in 1896 upon a sarcoma of the skull in the frontal region; the tumor grew in the diploë, and had not perforated the internal table. It was as large as a man's fist. The patient remained well for three years, when I lost sight of him.

Fig. 145.—Ulcerated Sarcoma of the Skull. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

CHAPTER XIV

THE INJURIES AND DISEASES OF THE BRAIN AND ITS MEMBRANES

GENERAL CONSIDERATIONS

Injuries and diseases of the brain give rise to symptoms and signs, local and general, some of which depend upon interference with the function of the brain, as a whole, and some upon disturbances of certain limited portions of brain tissue. If these disturbances occur in parts of the brain whose function is known, definite symptoms are produced, such that in some instances we are able to apply appropriate surgical treatment for relief. In many cases of injury the history of the accident, the presence of a wound, a fracture, of external bleeding, etc., may be sufficient guides to the seat of the trouble; in others we are obliged to depend upon the aforesaid disturbances of brain function.

Injuries of the brain are, however, often of a complicated character; the symptoms of cerebral shock or concussion may mask those of compression, contusion, or laceration. The lesions are often multiple. Many of them are soon complicated by infection and suppurative inflammation of the brain and its membranes of a progressive character, producing new local and general symptoms such that the symptoms of the original lesion are entirely overshadowed. Certain large areas of the brain may be injured or destroyed and yet no symptoms, or only indefinite symptoms, will follow; so that our ability to localize foci of injury or disease in definite portions of the brain is limited in many directions. The functions of certain portions of the brain are, however, definitely known as well as their relations to the surface of the cranium, and these data are at times valuable in the diagnosis and treatment of lesions of the brain, traumatic or pathological.

Cerebral Localization [1]

At the present time it is the generally accepted view that the Rolandic, or central, fissure divides the cortex of the brain into an anterior motor field and a posterior sensory field. This division of the brain was worked out by Professor Sherrington in the anthropoid apes, and has been shown to be true also for man by Krause, Frazier, and Cushing.

[1] Partly adapted from Harvey Cushing, "Keen's Surgery," vol. iii, p. 155 *et seq.*, W. B. Saunders, 1908.

The Motor Area of the Cortex.—Contrary to the former belief, which placed the motor area of the cortex both before and behind the central fissure, more recent investigations have shown that upon the exposed surface of the convexity of the brain the motor area is limited to a narrow strip about one centimeter

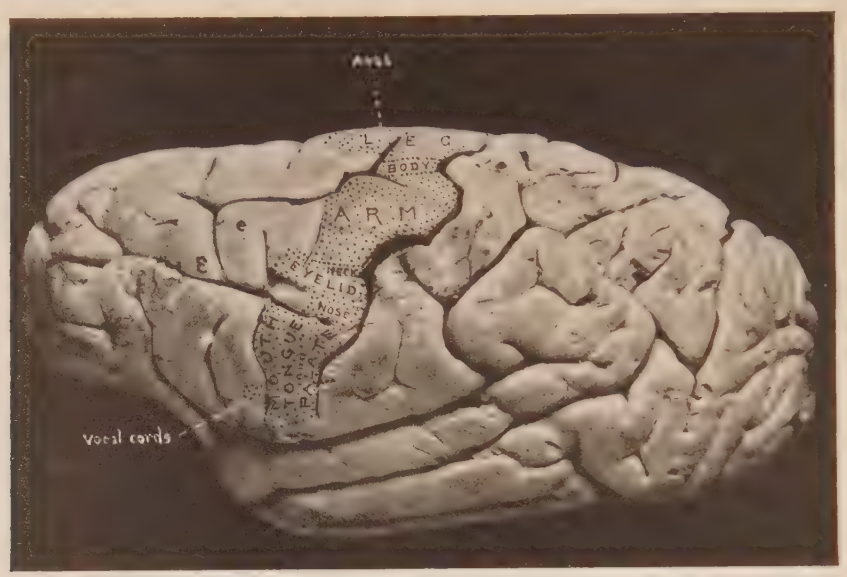


FIG. 146.—BRAIN OF GORILLA, SHOWING EXCITO-MOTOR AREA AS DELINEATED BY CORTICAL FARADIZATION. Note the presence of the three genua (*superior*, opposite body; middle, opposite neck areas). (Kindness of Prof. Sherrington.)

in width, situated in the anterior central gyrus, extending, however, to the depth of the central fissure. Thus a lesion involving the motor cortex may be removed some distance from the superficial portion of the brain. The upper limit overlaps on the mesial surface of the hemisphere (the paracentral lobule). The lower limit does not extend as far as the fissure of Sylvius.

The Rolandic fissure is not a straight line, but is broken by two, or sometimes three, more or less well-developed angles (genua), formed, I believe, by the swellings above and below them, made by the aggregations of cells controlling movements in the leg, arm, face, and, still lower down, jaws, tongue, etc. Opposite to the upper two genua the motor strip is less wide and its representative movements less complex, occurring as they do in the neck and trunk. Thus the genua are valuable surgical landmarks, particularly the middle and inferior ones, for they are more often brought into view. Above the superior genu there is but a small triangle of motor cortex which can be exposed, and it gives, on stimulation, movements in hip, knee, and toe; opposite to this genu lie centers for movements of thorax and abdomen; between it and the middle genu lie centers for the upper extremity, the shoulder being represented higher than fingers and thumb; opposite to the middle genu are centers for the neck, and below it those for the face, eyelids above and lips below; center for jaws, tongue, vocal cord, pharynx, etc., are the still lower, usually below an inferior genu (Cushing).

Destruction or removal of these areas produces motor paralysis of the corresponding muscles. Sensation is not affected.

Certain complex movements of a higher order may be obtained by stimulation of areas adjoining the true motor cortex. Thus, below the anterior central gyrus is the *pars opercularis*; sucking, chewing, sneezing, and vocalizing movements may be obtained (note that this is near the vocal speech center of Broca), and from the *gyrus frontalis medius* movements of the head and eyes to the opposite side may be elicited. The pathway from the motor cortex is the pyramidal tract, whose fibers degenerate throughout their full length after injury to their cortical cells (Cushing).

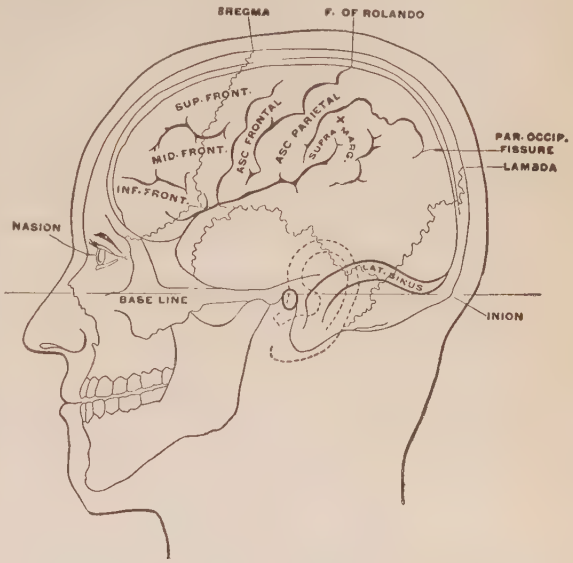


FIG. 147*a*. — DIAGRAM SHOWING THE RELATIONS OF THE MORE IMPORTANT FISSURES AND CONVOLUTIONS TO THE SUTURES AND BONY LANDMARKS OF THE SKULL. (From Woolsey.)

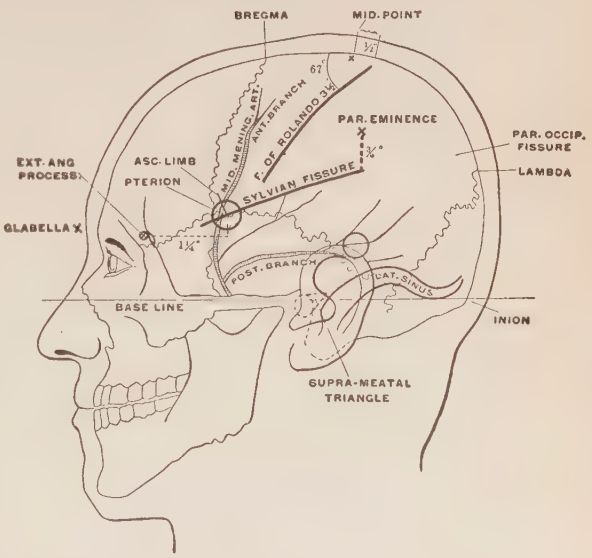


FIG. 147*b* — DIAGRAM SHOWING THE RELATIONS OF THE FISSURES OF ROLANDO AND SYLVIUS, THE MIDDLE MENINGEAL ARTERY AND THE LATERAL SINUS, TO THE BONY LANDMARKS AND SUTURES OF THE SKULL. (From Woolsey.)

The Sensory Field.—The sensory area for common sensation lies in the posterior central gyrus. The area occupies a position in the posterior central convolution similar to that of the motor area in the anterior central convolution. It lies largely in the cortex buried in the fissure, and occupies superficially only about half of the postcentral gyrus.

The fibers to the sensory field pass from the thalamus in the "cortical lemniscus" (Monakow) of the *corona radiata* to the post-Rolandic territory. In their course they lie in the posterior part of the capsula interna. The forms of sensation, registration of which we may now with some assurance place in the near post-central region, are the tactile sense, the muscular sense, and the power of discriminating points in contact. It is evident also that as one goes farther back from the *fissura centralis* and approaches the posterior association field of Flechsig, sensation

becomes more complex, so that more extensive and deeper lesions are necessary to interrupt its transmission. The senses of pain and of temperature lie probably in the intermediate post-central zone of Campbell, and that for the recognition of objects—the stereognostic sense in particular—is located as far back as in the parietal lobe (Walton and Paul).

The Visual Cortex.—The primary perceptions of sight are registered in the occipital lobe, especially on its mesial surface in the calcarine region.

The visuopsychic field extends on the outer surface (of the left side) in the second occipital convolution as far as the angular gyrus, where lies the visual word center (reading) which participates in the speech mechanism. The lingual lobule below the calcarine fissure appears to be associated with color perception.

The Auditory Cortex.—The superior temporal gyrus receives the sensations of sound which are converted into conscious perceptions in the adjoining portions of the temporal lobe, "those on the left side, in particular, being concerned with the auditory end of the speech mechanism. Extensive lesions on the right side may give rise to no appreciable impairment of hearing on the same side, and there is much confusion over the unilaterality or otherwise of the registration of auditory impulses."

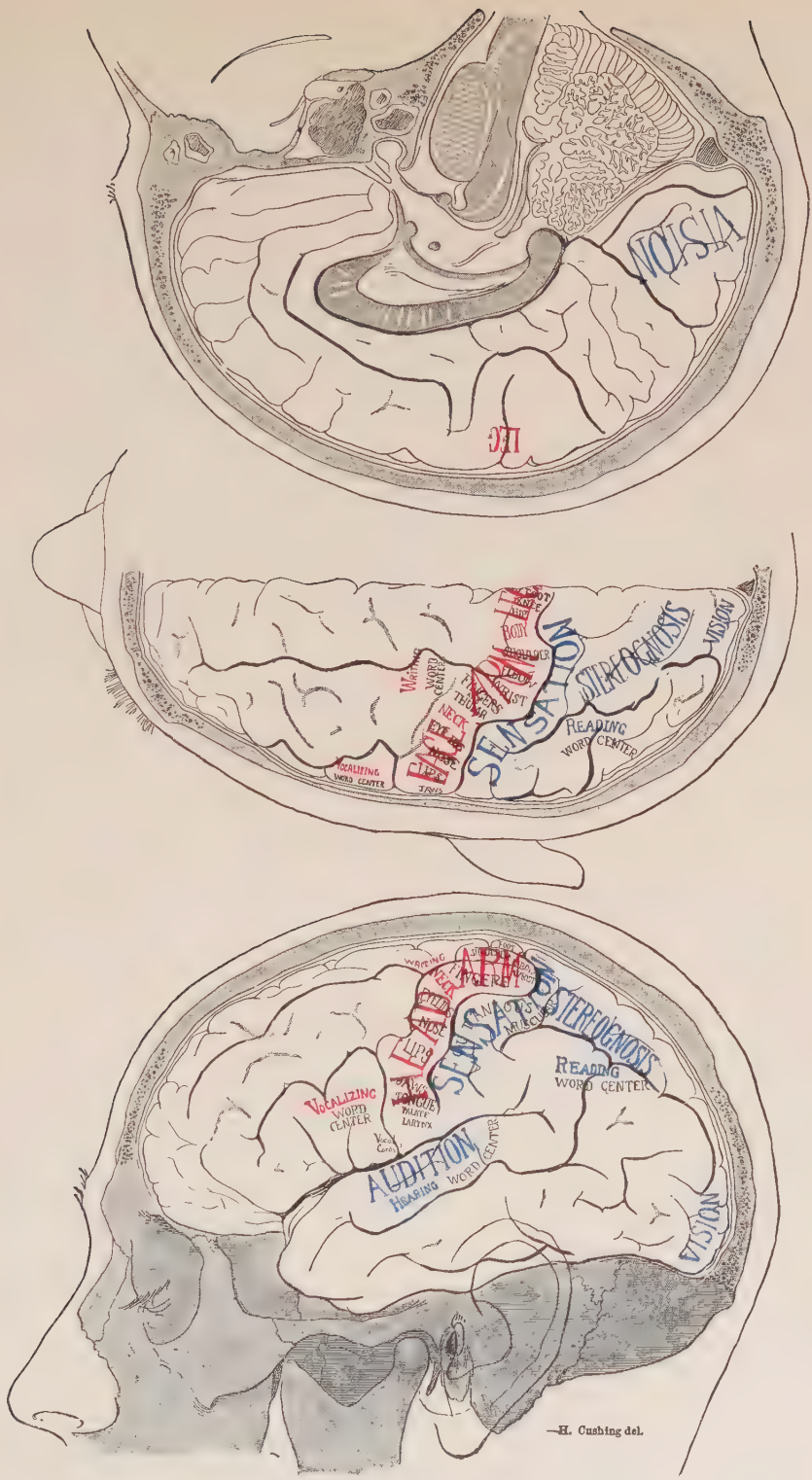
The Sense of Smell.—The pyriform lobe is generally regarded as the chief cortical center for the sense of smell.

The sense of taste lies probably at the lip of the limbic lobe, in the neighborhood of the uncus.

This, topographically speaking, would place both of these areas, for taste and smell, in a situation just to the outer side of the pituitary fossa—a matter of considerable importance, as lesions confined to this area of the limbic lobe not only give characteristic symptoms, but are surgically approachable (Cushing).

The Speech Areas.—The speech areas are in the left hemisphere in right-handed persons. They are four in number: (1) The area for the recognition of spoken words lies in the superior temporal gyrus. (2) The center for motor speech lies in the inferior frontal convolution. (3) The visual word center is in the angular gyrus. (4) The power of writing is lost when the median frontal gyrus is destroyed.

The General Cortex and Frontal Lobes.—There are large areas of the cortex whose function is unknown. They are more extensive on the right hemisphere than on the left. Many of these areas are doubtless concerned with the more complex mental processes (association). The frontal lobes of the brain apparently have to do with the higher mental faculties—i. e., attention, reasoning, and self-control—and lesions of the frontal lobes, notably upon the left side, are commonly attended by dullness, apathy, loss of the power of concentration, and imperfect self-control.



Diagrams Illustrating the More Definitely Localized of the Cortical Centers of the Exposed Parts of the Hemisphere, in Relation to the Main Fissures and Convolutions; also the "Word Centers" (Sensory and Motor) Involved in the Special Mechanism for Speech. (Receiving Sensory Stations in Blue; Discharging Motor Stations in Red.) Keen's Surgery.)

The Basal Ganglia.—The *corpora striata* and the *optic thalami* are not accessible to surgical treatment The same may be said of the *crura cerebri, corpora quadrigemina,* and pons. Lesions of the caudate and lenticular nuclei and internal capsule produce paralysis upon the opposite side of the body and, if the posterior part of the capsule is involved, sensory disturbances. Lesions of the optic thalami involving the internal capsule may produce disturbances of motion and of sensation upon the opposite side of the body, and in some cases hemianopsia. Lesions of the pons may produce palsies of the cranial nerves on the same side of the body, with paralysis of the extremities upon the opposite side.

The Cerebellum.—Lesions of the cerebellum produce disturbances of the equilibrium of the body when the patient walks, notably if the median lobe is involved. Such are staggering, vertigo, and muscular ataxia of the extremities. If the median lobe is involved the symptoms are bilateral. If a lateral lobe is involved the symptoms will be chiefly upon one side of the body; when walking, these patients are apt to stagger toward the affected side, or even to fall in that direction. Nystagmus and paralyses of the muscles moving the eye are common.

From the above briefly stated data the location of brain lesions must be, in part, derived. The general signs and symptoms of brain lesions are headache, vomiting without nausea, vertigo, optic neuritis (choked disk), convulsions, together with stupor or coma of any grade. The focal motor symptoms are partly irritative (muscular contractions or attacks of Jacksonian epilepsy) and partly destructive—i. e., paralyses of groups of muscles, or hemiplegia. From the situation of the spasms or paralyses it is sometimes possible to locate the lesion in the corresponding portion of the motor area. In some cases, as of a tumor or other progressive lesion, the symptoms begin with irritation and end in paralysis. Sensory symptoms are rarely definite enough to be localized. The interferences with speech are of several characters, and are to be referred to the areas already indicated.

Cranio-cerebral Topography

The relation of the fissures of the brain to bony landmarks on the surface of the skull has been worked out by various observers according to various plans. The three most important fissures, from a surgical point of view, are the *fissure of Rolando,* the *fissure of Sylvius,* and the *parieto-occipital fissure.*

The Fissure of Rolando.—The fissure of Rolando may be located as follows: A line is laid down from the root of the nose backward, over the middle line of the head to the occipital protuberance. Measure to a point 0.557 of this distance along this line backward, from the root of the nose; this point corresponds to the upper end of the Rolandic fissure. From this point the fissure runs downward and forward a distance of about three and one half inches, making an angle of sixty-seven degrees with the median line of the head. In

making the measurements two graduated strips of metal are used. One strip is fastened to the other at an angle of sixty-seven degrees. If these strips are laid upon the head in such a position that one of them overlies the sagittal suture while their junction is over the upper end of the Rolandic fissure, the second strip will pass downward and forward at an angle of sixty-seven degrees with the first, and will overlie the course of the fissure. The lower third of the fissure is a little more vertical than the strip.

The Fissure of Sylvius and the Parieto-occipital Fissure.—These two fissures are found as follows: "Lay down a base line from the lower margin of the orbit to the auditory meatus. Lay down a second line parallel to it from the external angular process of the frontal bone backward one inch and a quarter. Then measure upward one quarter of an inch. This is point one. Find the most prominent part of the parietal eminence, and from it draw a line downward perpendicular to the base line, and on this take a point three quarters of an inch below the eminence; this gives point two. Join these two points and the line will lie over the fissure of Sylvius. The anterior limb of the fissure will be two inches behind the external angular process. The fissure is about four inches long. To find the *parieto-occipital fissure*, continue the line of the fissure of Sylvius to the median line. At their junction lies this fissure. Since all areas now open to surgical operation can be located with a definite relation to these three fissures, no further rules are necessary." (Starr, "Organic Nervous Diseases," first edition, page 482.)

Localization of Fissures.—It is customary to mark the position of the fissure sought upon the scalp by means of a scratch or superficial cut with a scalpel. The several points may also be marked upon the skull itself with the edge of a chisel or punch, and the brain exposed by raising an osteoplastic flap or by making one or more trephine openings, enlarged with a rongeur as may be necessary. Aseptic technic permits large osteoplastic flaps to be raised with safety. The topography of the brain is thus more readily recognized. A number of forms of apparatus have been devised for the ready localization of the important fissures. Among the most complete is that of Krönlein. A number of ingenious methods have been devised by German, English, French, and American surgeons for the determination of the relations between the various convolutions of the brain and definite points upon the surface of the skull. For a full description of these the reader is referred to the very complete work of A. Chipault. It is to be remembered that at the present time small trephine openings are rarely used when operating upon the brain. The present practice is to make a large osteoplastic flap, and thus to expose so large an area of the brain that small errors in the situation of the incisions are unimportant. The method of Krönlein is complete and satisfactory. A cut of the apparatus used is here given, together with a short description of the lines and angles as constructed upon the skull.

The description is here given nearly in the words of the originator of the method. Five lines are used as a basis for the plan. They are:

1. The base line, or German horizontal line. Ear-orbital line (linea horizontalis, auriculo-orbitalis).
2. The upper horizontal line (linea horizontalis supra-orbitalis).
3. The anterior vertical line (linea verticalis zygomatica).
4. The middle vertical line (linea verticalis articularis).
5. The posterior vertical line (linea verticalis retromastoidea).
6. The linea Rolandi obliqua.
7. The linea Sylvii obliqua.

The points upon the skull from which these lines are to be drawn are easily found. The lines are drawn as follows:

(1) *The base line.* Through the inferior border of the orbit and the superior border of the auditory meatus. (2) *The upper horizontal line.* Through the upper border of the orbit parallel to the base line. (3) *The anterior vertical line.* From the middle of the zygoma upward at right angles to the base line. (4) *The middle vertical line.* From the head of the articular process of the inferior maxilla upward at right angles to the base line. (5) *The posterior vertical line.* From the most posterior point of the base of the mastoid process upward at right angles to the base line. The two oblique lines are secondary constructions. They are drawn as follows: (6) *The linea Rolandi.* The line of the Rolandic fissure from the point of intersection of the anterior vertical line with the superior horizontal line to the point where the posterior vertical line meets the sagittal suture (middle line of the head). (7) *The linea Sylvii* of the fissure of Sylvius is a line corresponding to half the angle made by the Rolandic line and the superior horizontal line, and prolonged backward until it meets the posterior vertical line.

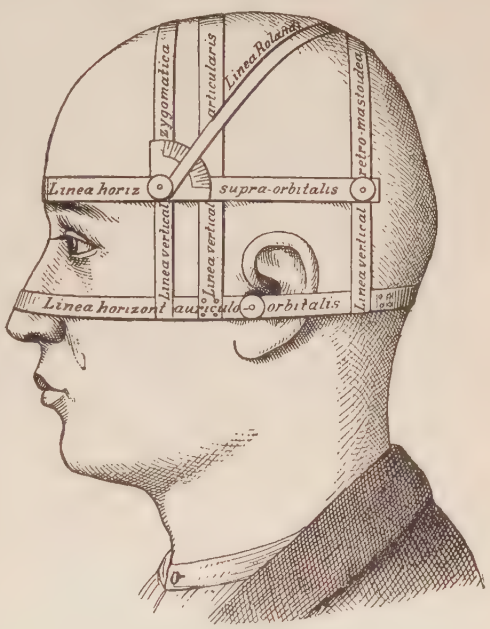


Fig 148.—Krönlein's Craniometer.

In the diagram (Fig. 149) the letters have the following significance: *K*, point of division of the fissure of Sylvius. *S*, upper end of the fissure of Sylvius. *R*, lower end of the Rolandic fissure. *P*, upper end of the Rolandic fissure. *K* and K^1, points for the application of the trephine to reach the sources of hemorrhage in rupture of the middle meningeal artery. *A*, *B*, K^1, *M*, quadrilateral area in which, according to von Bergmann, the skull may be resected by an osteoplastic flap to reach abscesses in the temporal lobe of the brain fol-

lowing otitic disease. The several lines and angles of the diagram may be constructed upon the head without the aid of special apparatus, but the method is rendered simpler and easier by the use of Krönlein's cranionieter, an instrument applied to the head (as seen in the illustration); from what has preceded, no further explanation of its use is required.

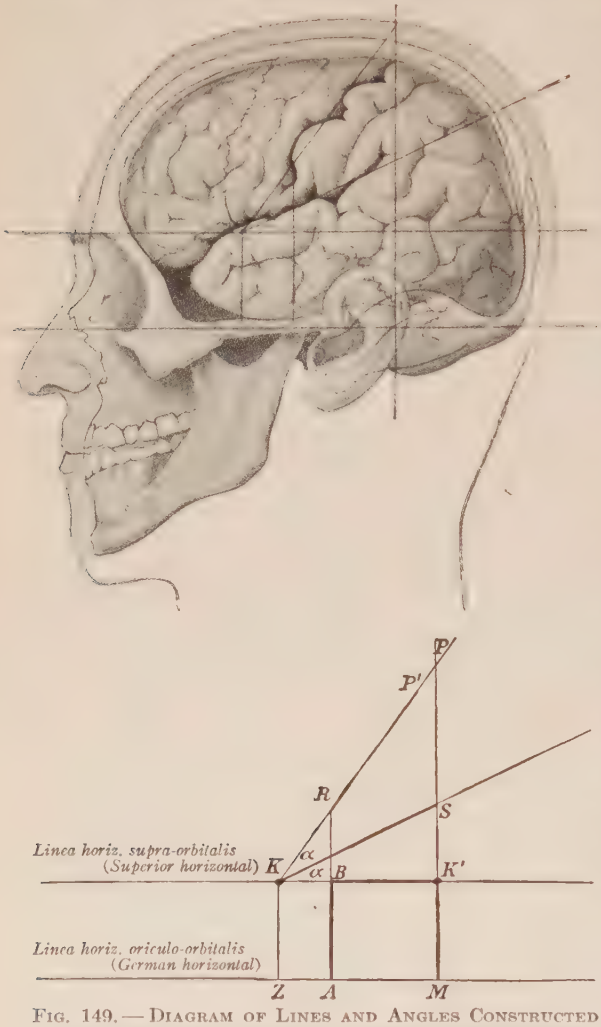


FIG. 149.—DIAGRAM OF LINES AND ANGLES CONSTRUCTED UPON THE SKULL FOR THE LOCATION OF THE CONVOLUTIONS AND FISSURES. (Krönlein.)

INJURIES OF THE BRAIN

Concussion of the Brain, Commotio cerebri, Cerebral Shock.—By these terms we designate the condition following generalized injuries to the head in which no recognizable lesion of the brain is discoverable, but which present symptoms of temporary impairment or abolition of the functions of the brain as a whole. The symptoms appear at once on receipt of a blow or fall upon the head. The patient suddenly becomes unconscious; he is stunned and falls inanimate. The unconsciousness may be momentary or prolonged. In mild cases recovery begins at once; the patient regains consciousness, but is giddy, weak, has headache, is dull and confused for some minutes or hours. The occurrences immediately preceding the accident and the accident itself are forgotten. In more severe cases unconsciousness lasts for minutes or hours; shock is more pronounced; the surface is pale; the pulse is slow, feeble, and compressible; respiration is superficial, irregular, or stertorous. The conjunctiva is insensitive and normally painful irritations of the skin produce no reaction. The pupils are equal, normal, contracted or dilated, but responsive to light. Repeated vomiting is common. There may be convulsive twitchings of the limbs. Recovery is gradual. Headache, confusion of mind, muscular ataxia, retention

or incontinence of urine and feces may be present. For a time the patient may be wholly or partly aphasic. The symptoms gradually pass away after hours or days. During recovery the patient lies in bed on his side in a position of general flexion; he is irritable and does not wish to be disturbed. During this time the face may be flushed, the eyes bright and suffused. The pulse is rapid and of high tension. The sooner and more complete the return to consciousness, the more probable it is that the condition is merely that of cerebral shock.

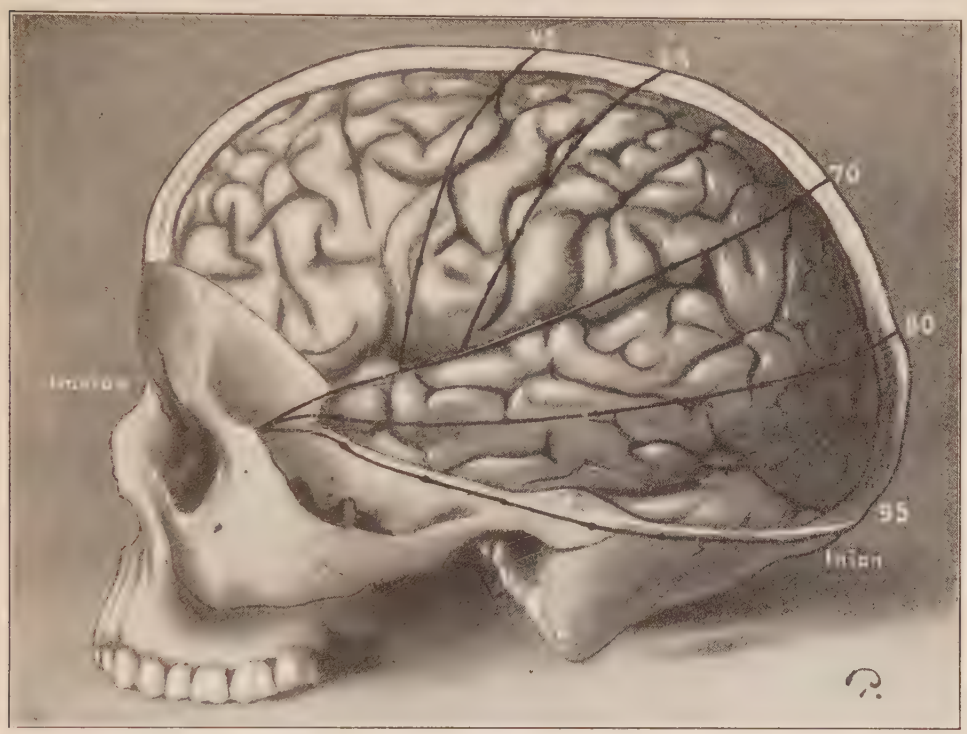


Fig. 150.—Chipault's Method of Cranio-cerebral Localization by Angles and Measurements. (Kindness of Dr. Frank Hartley.)

This method is dependent on a percentage basis, and therefore is particularly accurate regardless of how sex, age, or race may vary the size or shape of the head. The distance from the *nasion* or *naso-frontal suture* over the midline of the vertex to the *inion* or *external occipital protuberance* is measured and marked on the scalp. On this line, always measuring from its anterior end or nasion, the following percentages of its length are marked: 45 per cent, 55 per cent, 70 per cent, 80 per cent, and 95 per cent. The *retro-orbital tubercle*, a small projection of bone on the posterior border of the frontal process of the malar bone, is located and its position marked on the scalp. A line is drawn from this *retro-orbital tubercle* to the 70 per cent point, measured and divided into tenths. The junction of the second and third tenths is joined to the 45 per cent point and the junction of the third and fourth is joined to the 55 per cent point. The *retro-orbital tubercle* is also joined to the 80 per cent point and to the 95 per cent point.

The line to the 45 per cent corresponds to the *precentral fissure.*
The line to the 55 per cent corresponds to the *Rolandic fissure.*
The line to the 70 per cent point corresponds to the *Sylvian fissure.*
The line to the 80 per cent point corresponds to the *superior temporo-sphenoidal fissure.*
The line to the 95 per cent point corresponds to the *lateral sinus.*
For more accurate and detailed localization all these lines may be divided into tenths.

When the unconsciousness is prolonged for hours or days, the diagnosis of mere cerebral shock can hardly be made. It is probable that contusion or laceration of the brain or greater or less severity is present.

Compression of the Brain.—Compression of the brain may be due to anything which causes a sudden continuous increase of intracranial tension—effused blood, displaced fragments of bone in depressed fractures of the skull, foreign bodies, and inflammatory exudates. As the result of accidental injuries the symptoms of compression of the brain are usually associated with those of cerebral shock, or of contusion or laceration of the brain. In pure cases of compression—such as sometimes accompany rupture of the middle meningeal artery and intracranial hemorrhage—a distinct interval occurs between the accident and the onset of typical symptoms; such may be hours or days.

Symptoms.—The symptoms may be described under two heads: Symptoms of irritation, followed by the true symptoms of compression. At once, after the accident, the patient suffers from headache; he is often excited and irritable. The face is sometimes flushed; the pulse is slow and of high tension. The pupils are equal and often contracted; nausea and vomiting are common. The patient gradually becomes dull and stupid, and finally falls into a deep sleep, which is followed by coma. With the onset of coma the second set of symptoms are developed. They consist of the coma, of changes in the pupils of the eyes; the pupil on the side of the injury is at first contracted, and later dilated and wider than that of the other eye. There occur also paralyses, either limited to one particular limb or group of muscles, or hemiplegia, or paraplegia. The oculo-motor nerve is often affected. There may be squint or a slow rolling of the bulb of the eye. Observation of the fundus of the eye frequently shows choked disk. If, as is rarely the case, the compression of the brain is very sudden, there may be convulsive movements of the extremities. The heart beats slowly, respiration is slow and stertorous, and may be irregular. As a fatal issue approaches, respiration may cease for a minute or more, and then be resumed. The heart may continue to beat for several minutes after respiration has ceased. Inequality and insensitiveness of the pupils indicates a serious or high degree of compression. If they are equal, or continue to respond to light, the compression is not severe. The more widespread the paralysis the larger the hemorrhage. A limited paralysis indicates hemorrhage between the dura and the skull. A widespread paralysis, hemorrhage beneath the dura. The paralyses are on the side opposite the compression.

Injuries of the Blood-vessels of the Brain.—Injuries of the Sinuses.—Injuries of the sinuses of the brain occur as the result of fractures or of wounds, such as gunshot or stab wounds of the skull. They may be produced by depressed bone fragments, which lacerate the wall of the sinus; or ruptured by displacements of bone in fractures of the skull, or during labor. If the wound of the sinus communicates with an external wound, there will be venous bleeding, which is usually easily controlled by pressure. The superior longitudinal sinus is most often wounded, and the transverse sinus rarely. If the injury is subcutaneous, so that the blood cannot escape, it may accumulate between the dura and the skull, or beneath the dura, and produce symptoms of compression of the brain. The onset of the symptoms is much slower than after

arterial hemorrhage, and of less intensity, indeed, in many cases of injury to the sinuses, the symptoms of compression are entirely wanting.

Injury of the Arteries in the Cranial Cavity.—Hemorrhage, or bleeding from the middle meningeal artery, has already been described under Fractures of the Skull.

Injury of the Internal Carotid Artery.—On account of its deeply placed position, the internal carotid artery is much less often wounded than the middle meningeal. The artery may, however, be injured by a sharp fragment of bone in fractures of the base of the skull; as the result of gunshot wounds; occasionally from stab wounds through the orbit which penetrate the skull. If the artery be wounded in the cavernous sinus, an arterio-venous aneurism may develop and produce a pulsating exophthalmos. Injuries of the carotid in this situation are sometimes accompanied by paralysis of the abducens or motor oculi nerve. Generally speaking, rupture of the internal carotid artery is a rapidly fatal injury from intracranial hemorrhage and the symptoms of pressure upon the brain, sudden coma, and death.

Intracranial Hemorrhage between the Dura and the Pia.—Intracranial hemorrhage between the dura and the pia occurs as the result of injuries to the head, notably those involving laceration of the brain substance. It occurs usually from small blood-vessels or from a venous sinus. The amount of blood extravasated may be large or small. The blood spreads itself over the surface of the brain, and its accumulation may be followed by the symptoms of compression. These symptoms are much more slowly developed, and of less intensity than are observed after rupture of the middle meningeal artery. If the extravasations are moderate in amount, and do not invade one or other of the areas of the cortex presiding over some definite function, they may produce no symptoms at all. Rupture of one of the larger arteries of the brain itself is usually attended by a rapidly fatal result with the symptoms of sudden compression of the brain.

Injuries of the Cranial Nerves within the Skull.—When the cranial nerves are injured within the skull paralyses occur on the same side of the body as the injury.

The Olfactory Nerve.—The olfactory nerve is sometimes ruptured in fracture of the base of the skull involving the anterior fossa, occasionally by wounds, or falls upon the forehead, sometimes by falls upon the occiput. Injuries of the olfactory nerve are attended by the loss or diminution of the sense of smell. The sense of taste is so much a part of the sense of smell that the loss of the latter is attended by a diminution of the former.

The Optic Nerve.—Complete division of the optic nerve is attended by blindness in the corresponding eye. Contusion of the nerve or pressure by a blood clot may be wholly recovered from. (See case described, p. 409, pistol-shot wounds of the anterior fossa of the skull in which there was also ptosis and dilated pupil, significant of injury of oculo-motor nerve.)

The Oculo-motor Nerve.—The third nerve may be injured by the pressure of the forceps during parturition and as the result of fractures of the anterior fossa and of wounds of the orbit. The symptoms of paralysis of the third nerve are ptosis—i. e., falling of the upper eyelid, dilatation of the pupil, with loss of reflexes both for light and distance. The eyeball is turned outward and a little downward.

Trochlear Nerve.—Injury of the *trochlear nerve*, with the production of diplopia, has been occasionally observed after severe injuries of the head.

The Fifth Pair of Cranial Nerves.—The fifth pair of cranial nerves is rarely injured alone in fractures of the base of the skull, but its injury is very commonly associated with injuries of the other pairs of cranial nerves in these fractures. If the paralysis be complete, the insensitiveness of the conjunctiva leads to trophic ophthalmia, probably because the conjunctiva, being insensitive, the pressure of foreign bodies and other sources of irritation is not observed by the patient. Also, it is believed, on account of the trophic nerves which accompany the fibers of the fifth pair.

Paralysis of the Abducens Nerve.—Paralysis of the abducens nerve is infrequent. It may accompany the formation of an arterio-venous aneurism between the internal carotid and the cavernous sinus. The symptom of paralysis of the sixth or abducens nerve is internal strabismus.

The Facial Nerve.—The facial nerve is not infrequently injured during instrumental delivery, but the paralysis is not permanent. It is very often injured in fractures of the base of the skull which pass through the petrous portion of the temporal bone, and the injury is commonly associated with that of the nerve of hearing. In these cases the lesion is almost always upon one side only. The paralysis is quite apt to be permanent. Erb states, that if the soft palate is not paralyzed, then the facial is injured below the geniculate ganglion—that is to say, below the point of origin of the great superficial petrosal nerve. If the soft palate is paralyzed the injury is above the ganglion.

The Acoustic Nerve.—Injuries of the acoustic nerve occur less often in fractures of the base of the skull than is the case with the facial. Loss of the sense of hearing may, however, occur from hemorrhage within the labyrinth, or within the middle ear, without the presence of fracture. If facial paralysis and deafness exist upon one side, with paralysis of the sense of taste, the nerves have been injured in the neighborhood of the internal meatus (Tillmans). One case of injury of the *glosso-pharyngeal nerve* is related by Pirogoff. Following a blow upon the neck, there occurred disturbances of speech and swallowing, the root of the tongue ulcerated. Death occurred from edema of the glottis. The autopsy showed a hemorrhage in the form of a clot in the root of the glosso-pharyngeal nerve. Paralyses of the other cranial nerves as the result of injury within the skull are exceedingly rare.

Contusion, Laceration, and Wounds of the Brain.—Contusion and laceration of the substance of the brain occur as the result of direct or indirect violence applied to the skull, or to the brain itself, as the result of blows, falls, gun-

shot or other wounds. The severer forms are nearly always complicated by fracture of the skull. The lesions vary from the production of minute punctate hemorrhages into the substance of the brain, to disorganization of the entire brain, or of a limited area thereof, of any size. The injury to the brain may be at the point of application of the force or at a distant point, sometimes upon the opposite side of the head.

Symptoms.—The symptoms depend upon the portion of the brain injured. As has been pointed out, injuries or destruction of certain parts of the brain are not necessarily accompanied by recognizable symptoms. The symptoms of cerebral shock are common, and are often combined with those of intracranial bleeding and compression of the brain. There are, moreover, special symptoms when certain parts of the brain are involved. These will correspond with the areas presiding over motion, sensation, vision, speech, etc.—as described in the section on Cerebral Localization. In general, it may be said that cases of injury to the head—followed by localized palsies, not presenting symptoms of compression—are due to contusion and laceration of the brain. The paralyzed muscles undergo subsequent contracture. Soon after the injury clonic spasms may occur. Broncho-pneumonia is a common complication, due to aspiration of vomited matter, etc., into the lungs during unconsciousness. Subcutaneous injuries of the brain usually run an aseptic course. If open wounds exist, and are infected, the symptoms of meningitis, sinus thrombosis, abscess of the brain, etc., are added.

Interesting and important as is the topic, want of space forbids a discussion of the details of cerebral localization *in extenso*. The reader is referred especially to "A Handbook of Practical Surgery," vol. i, E. von Bergmann; Starr, "Organic Nervous Diseases"; Gowers, Chipault, and Bailey. A knowledge of the physiology of the brain will, in general, suffice for a correct interpretation of local symptoms.

As has already been noted, foreign bodies—notably bullets of small caliber fired at low velocities—may remain indefinitely in the brain and produce no symptoms; their location can be determined by means of X-ray pictures. On the other hand, abscess of the brain may cause death after a long interval of apparent immunity. In other cases the injured portion of brain may undergo softening due to changes (fatty degeneration) in the blood-vessels. Such changes may be progressive and finally interfere with the nutrition of portions of the brain presiding over vital functions; paralyses or fatal coma follow. The symptoms resemble those of abscess of the brain. Some years ago I saw such a case in the person of a distinguished medical man who was brought to the hospital comatose, with fracture of the base. After many weeks of total—later partial—unconsciousness, deafness in one ear, facial paralysis, he apparently became convalescent. Rather sudden fatal coma supervened. The autopsy showed a fracture of the base through the middle and anterior fossæ of the skull upon one side, and a large area of red softening upon the opposite side of the brain which had extended deeply in from the cortex to involve

the pons and a portion of the medulla. Following contusion of the brain, epilepsy and psychoses are not uncommon. Epilepsy, especially, follows injuries of the medulla and the motor area of the cortex.

Prolapse of the Brain through a Wound.—Prolapse of the brain through a wound sometimes occurs after compound fractures of the vertex with loss of substance and of wound of the dura. The character of the brain tissue is easily recognized. True hernia of the brain may occasionally remain (encephalocele). Ordinarily the protruding mass constitutes what is known as fungus cerebri. The exposed brain becomes covered by granulation tissue

Fig. 151.—Fungus Cerebri Following an Operation for Compound Depressed Fracture of the Skull. (Kindness of Dr. J. C. Ayer.)

and forms a dirty-white, pink, or red fungating tumor which projects above the level of the scalp, and may pulsate while it is small; later, pulsation usually disappears. It is painless and insensitive; bleeds readily. If infected it may become gangrenous or cause meningitis, etc. Firm pressure upon it may cause mild symptoms of cerebral compression, giddiness. The tumor increases in size on coughing, sneezing, straining, etc. After healing takes place a marked depression is left at the site of the former protrusion. In rare cases a protrusion remains after healing is complete.

Inflammation of the Dura Mater—Pachymeningitis.—Inflammation may occur on the outer or internal surface of the dura—pachymeningitis externa and pachymeningitis interna—or both. Purulent inflammation of the dura occurs as the result of infected fractures of the skull, and of suppurative processes of the soft parts of the head and face and orbit, not infrequently

as a complication of acute or chronic suppuration of the middle ear, or as an extension from purulent infection of the cranial bones following injury or disease; sinus phlebitis, inflammation of the pia, encephalitis, and abscess of the brain are common associated lesions.

Pachymeningitis externa alone, if the purulent exudate be large in amount, may produce symptoms of compression of the brain. The purulent collection may be protected from extension by adhesions and the formation of granulation tissue, and remain latent for an indefinite time. Headache, fever, tenderness on pressure, very rarely focal symptoms, may be present. There will nearly always be an infected wound or fracture and a local suppurative process, middle-ear disease, caries or necrosis of the cranial bones, etc. The importance of pachymeningitis arises largely from the associated lesions to which it gives rise—sinus phlebitis, meningitis, abscess of the brain, etc.

Inflammations of the Venous Sinuses of the Dura Mater.—Purulent infection of the sinuses of the dura mater occurs as the result of infectious processes of the soft parts of the head and face, infected fractures of the skull, and purulent infection of the cranial bones. The most common cause of all is suppurative inflammation of the middle ear and mastoid process of the temporal bone, acute or chronic. It is seldom that the symptoms of sinus inflammation exist alone; they are nearly always combined with those of the middle ear and mastoid disease, or with meningitis, abscess of the brain, an infected fracture, erysipelas, anthrax, a phlegmon of the face and scalp, or some other septic condition. The regular ending of purulent inflammation of the sinuses is pyemia.

Inasmuch as inflammations of the middle ear and the mastoid process are the causative factor in two thirds of the cases, the lateral sinus is more often affected than any other. The wall of the sinus becomes infected by continuity of structure through its wall (thrombophlebitis) or a minute vein in the site of the primary focus becomes infected and thrombosed and the thrombosis spreads along the vein to the sinus. The general symptoms are those of pyemia—chills, fever, sweating, etc. In the early stages the symptoms referable to the brain are those of irritation and compression—headache, sometimes followed by delirium and coma, nausea and vomiting. Later, as a result of a complicating meningitis, there may be convulsions and paralyses.

In the absence of meningitis or abscess of the brain, the process may run its course as a pyemia without the development of cerebral symptoms. In some instances the thrombosis may extend downward into the internal jugular vein, usually not lower than its upper third, which may sometimes be felt as a hard cord along the anterior border of the sterno-mastoid muscle. The involvement of the cavernous sinus is commonly attended by congestion of the eyeball, sometimes by moderate exophthalmos and engorgement of the superficial veins of the eyelids and forehead. The nerves in the vicinity of the sinus may be partly or totally paralyzed—in this case the oculo-motor, the trochlear, the abducens, and the first branch of the fifth pair. The move-

ments of the tongue may also be affected by pressure upon the hypoglossal nerve.

When the disease begins in the middle ear or the mastoid process the Streptococcus pyogenes and the pneumococcus are the organisms most often found. There will be the history of an acute or chronic inflammation of the middle ear, discharge from the external ear, and deafness, tenderness and swelling over the mastoid process (see Ear), sometimes facial paralysis. In some cases the infection of the vein is accompanied by the production of a localized abscess either extra-dural or subdural; in such cases there will be severe headache, sometimes choked disk, the symptoms of pressure upon, or irritation of, the pneumogastric, a rapid or slow pulse. Infection of the superior longitudinal sinus occurs especially after gunshot wounds and infected fractures of the skull; there are rarely any localizing symptoms other than those of meningitis and pyemia.

Primary Meningitis—Acute Suppurative Inflammation of the Pia Mater (*Leptomeningitis*).—Primary meningitis occurs most often as the result of direct traumatisms to the head (infected fractures, stab and gunshot wounds, and the like), rarely as the result of hematogenous infection. While purulent inflammations of the external surface of the dura tend rather to remain localized, those of the pia tend to spread rapidly and to involve a large part, or even the entire surface, of the convexity and base of the brain. The cases may be divided into two types: Those in which infection takes place at the time of the injury, or very soon thereafter, and those in which the pia is not infected until later, during the healing process, and thus the appearance of symptoms may be delayed for weeks or months—early and late meningitis (Krönlein). The pyogenic organisms are the cause of the infection.

In the late cases the conditions favoring the occurrence of meningitis are necrosis of the injured tissues, imperfect drainage, the presence of foreign bodies, of loose splinters of bone, sinus thrombosis and phlebitis (Krönlein). In the early cases the pia may be inflamed a few hours after the injury, and thus the symptoms are often combined with those of cerebral concussion, compression, or contusion and laceration. The late cases are frequently complicated by encephalitis, purulent softening of the brain and abscess; it is, therefore, difficult to draw a typical clinical picture of meningitis.

The early cases usually run an exceedingly acute course; as a rule the disease ends in death in a few days. In many instances following an open injury to the head, usually a fracture, the patient will have a chill, accompanied by a rise of temperature and a rapid pulse, headache, nausea, and vomiting. He will be very restless and suffer from extreme thirst, the pupils of the eyes will be contracted, the restlessness will be followed by delirium, and the delirium by stupor, coma, and death. There may be no localizing symptoms whatever. In such cases the locality of the process can only be inferred from the situation of the wound.

In other cases the general symptoms will be accompanied by special symp-

toms referable to some particular part of the brain. Muscular rigidity of one or more limbs, or of groups of muscles, notably the muscles of the back of the neck in meningitis involving the base of the brain. There may be convulsive twitchings or clonic convulsions of the limbs, or evidences of irritation in the areas supplied by one or other of the cranial nerves, the adbucens, the oculo-motor, the facial nerves, or Cheyne-Stokes respiration, or difficulty in swallowing. There may be paralysis of an extremity or hemiplegia. It may thus be possible to say that the meningitis involves one or the other side of the head, or is more intense upon the convexity, or upon the base of the brain (Krönlein). The course of the disease, once inaugurated, is as acute in the late as in the early cases. Purulent meningitis may also occur as well through infection of wounds in the mucous membrane of the nose, the pharynx, or the middle ear, complicating fracture of the base, as from wounds and fractures upon the convexity of the skull.

Secondary Meningitis.—In addition to meningitis from wounds, infection may occur secondarily, by continuity of structure, or through the medium of the blood and lymph channels during acute and chronic suppurative processes of the soft parts or the bones of the skull and face, notably the middle ear, or occasionally in the course of pyemia; the symptoms are the same as in the traumatic form.

THE DISEASES OF THE BRAIN

Abscess of the Brain.—Abscess of the brain may be either acute or chronic, and may result from injuries, infected fractures of the skull, contusions and lacerations of the brain which become infected, or as the result of diseases of the skull, the brain or its membranes, such as tuberculosis, syphilis, actinomycosis, sometimes in the course of pyemia as a metastatic process. It is a very frequent complication of disease of the middle ear. Acute abscess of the brain following injury may be simply a part of an acute meningitis, accompanied by septic infection and purulent softening of a circumscribed portion of the brain infected at the time of the injury, or it may occur some time after the original injury, as the result of a late infection of a contused and lacerated area of the brain substance. If such an area communicates directly and freely with the external wound, the pus may be discharged externally and healing by granulation is possible. In some cases such a purulent collection may remain encapsulated for an indefinite time, and produce no symptoms for months, or years, so long as no important portion of the brain is invaded. Sooner or later the abscess may increase in size and produce death by rupture and purulent meningitis, or by rupture into the lateral ventricle, or by invading some vital portion of the brain tissue. The metastatic abscesses of the brain, occurring in the course of pyemia, may be single or multiple, and give rise to definite symptoms, or not, according to their location. Aside from traumatisms to the head, chronic disease of the middle ear is the most frequent cause of abscess of the brain.

Symptoms.—The symptoms of abscess of the brain depend partly upon the locality of the abscess and partly upon the septic nature of the process and partly, although rarely, upon the production of compression of the brain. When a brain abscess communicates with an open fracture of the skull, which is evidently infected and discharging pus, its location offers no difficulties. In the more chronic forms of abscess, persistent localized headache corresponding to an area of tenderness upon percussion, the occurrence of irregular attacks of intermittent fever, are sometimes important aids in the diagnosis. Localizing symptoms of destruction of, or pressure upon, definite portions of the brain, may be present or absent, according to the situation of the abscess; if present, they will vary according to the locality of the abscess. (See Cerebral Localization.) The diagnosis of acute abscess of the brain following injury may be impossible on account of the complicating conditions, meningitis, etc.

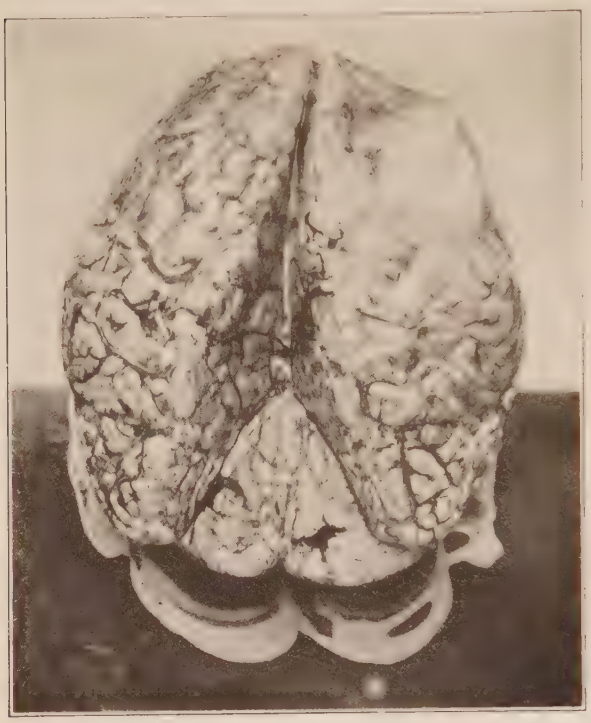


Fig. 152.—Abscess of the Cerebral Cortex (Frontal) Following a Very Severe Burn of the Scalp which became Infected and Ended in the Production of a Fatal Abscess of the Brain. The vitality of the skull was seriously impaired by the original burn. There were no focal symptoms. (New York Hospital, author's collection.)

Diagnosis of Chronic or Latent Abscess of the Brain.—The diagnosis of chronic or latent abscess of the brain following injury is characterized by the history of a wound or fracture of the skull which has been more or less infected. The brain symptoms which followed the injury, if such were present, usually disappear, the patient feels relatively or completely well. Such a period may last for two or three weeks or for as many years. The symptoms which follow this period may come on gradually or suddenly. They consist of pain and headache, which may be referred to the original wound or scar. Frequently there is trigeminal neuralgia of great severity. Accompanying the headache, etc., there is fever of a moderate grade, often intermittent. The patient may now be suddenly seized with spasmodic contractions of the muscles, of a local or general character. Sometimes a typical attack of epilepsy will occur; this may be repeated, and be followed by

an attack of hemiplegia and death, with the symptoms of an ordinary apoplexy.

"In cases where an injury of the head is followed some time afterwards by evening rises of temperature, by headache, convulsive attacks, and paralyses upon the side of the body opposite to the original injury, it is possible that an abscess of the brain exists" (v. Bergmann).

Abscess of the Brain Following Middle-ear Disease.—The diagnosis depends first upon the presence or a history of disease of the ear; further, as has been stated of abscess of brain elsewhere, upon symptoms due to sepsis, to paralyses, or symptoms of irritation of definite portions of the brain (localizing symptoms), to symptoms of cerebral compression. Fever is inconstant, rarely marked, often intermittent. A daily evening rise of temperature, with morning remissions, suggests other forms of intracranial suppuration rather than abscess, and sharp attacks of intermittent fever to involvement of the mastoid cells. In cases of abscess the patients complain of loss of appetite, of constipation, of weakness and lassitude, notably in the evening, sometimes of chilly sensations. Headache is fairly constant, and is made worse by percussion upon the skull over the affected area; it is often worse in the evening or when fever is present. Vomiting, occurring at irregular times irrespective of the ingestion of food, upon exertion or upon rising from a sitting posture, is fairly constant and characteristic. The pulse is usually slow.

Certain mental symptoms are present. Cerebration is sluggish, the patients are inattentive, do not readily comprehend what is said to them, and answer questions slowly and with effort. They are inclined to sleep a great deal, and are irritable. Examination of the eyes often shows choked disk upon the affected side. Localizing symptoms may be absent. Deafness and facial paralysis may be present, but are often due to the disease of the ear itself and to caries of the petrous portion of the temporal bone. When the disease is upon the left side and the abscess is in the temporal region of the brain, about half the cases will be affected with sensory aphasia more or less complete. These disturbances of speech are rarely very pronounced, and are often transitory. Those abscesses situated in the temporal lobe of the brain frequently give no pressure symptoms whatever, and often no localizing symptoms of any kind. The deafness, the facial paralysis, dilatation of the pupil upon the affected side, are believed, in the majority of instances, to depend upon the disease of the petrous portion of the temporal bone, or upon external pachymeningitis.

The abscesses which are situated in the cerebellum give even fewer localizing symptoms than those already spoken of. They are, perhaps, more often combined with or overshadowed by the symptoms of meningitis, pachymeningitis, sinus thrombosis, and pyemia. An uncertain, staggering gait, rigidity of the muscles of the back of the neck, and sometimes giddiness, point to the location of the abscess in the cerebellum. The methods of seeking for abscess

of the brain and of opening the skull belong rather to the domain of operative surgery.

Abscesses of the Brain Secondary to Infectious Processes of the Nose and the Frontal Sinus.—Abscesses of the brain secondary to infectious processes of the nose and the frontal sinus seldom give any localizing symptoms, unless they are of such large size as to reach backward to the motor areas or the speech center. They also are usually combined with meningitis, suppuration in the cavernous sinus, etc. They follow disease of the bones and infected fracture, notably gunshot fractures situated in the forehead, in the orbit, the upper jaw, the ethmoid bone. Chronically suppurating wounds and fractures involving the anterior fossa of the skull may give rise to the suspicion of abscess of the brain when the patient begins to lose strength, to suffer from headache, to feel dull, to vomit when his stomach is empty, and to have chilly sensations in the evening.

Differential Diagnosis.—The following differential diagnosis between meningitis, abscess of the brain, and sinus thrombosis is taken from Starr's "Brain Surgery," p. 190.

In meningitis there is usually a more rapid onset and progress of the symptoms than in brain abscess. In meningitis the headache is associated with hyperesthesia to sound and light and touch all over the body, symptoms usually absent in cerebral abscess. In meningitis the temperature is high and the pulse is rapid, irregular, and intermittent. In meningitis there are occasional spasms and convulsions; strabismus appears and trismus is common; and pain and rigidity along the neck are complained of as the disease advances. Thus there are numerous points which distinguish the two diseases from one another. Sinus thrombosis has also numerous points of differentiation from cerebral abscess. High fever with pyemic variations in its range and frequent chills; a very rapid pulse, swelling and edema over the mastoid process and edema of the neck, swelling along the jugular vein, which stands out like a hard cord in the neck, exophthalmos and even swelling of the conjunctiva, and marked venous stasis in the vessels of the scalp, are all symptoms not observed in cerebral abscess, but characteristic of sinus thrombosis. Choked disk appears early in the course of the case, while it is often wanting in cerebral abscess.

Tumors of the Brain.—A small proportion only of tumors of the brain cause symptoms such that they can be accurately localized, and a still smaller proportion afford a favorable field for surgical interference. Starr estimates that not more than seven per cent of all brain tumors can be operated upon with a prospect of success. It is, of course, of the utmost importance that the diagnosis be made at the earliest possible moment if an operation is to be undertaken. Sarcoma, glioma, gliosarcoma, and fibroma are the commonest forms of tumor which occur primarily in the brain. Carcinoma of the brain is secondary to carcinoma elsewhere in nearly all cases. Gummata, tubercular infiltration, and echinococcus cysts are usually grouped with brain tumors because they cause similar symptoms. In America, echinococcus is much less common than on the Continent of Europe.

The accompanying photograph is of the brain of a man who was admitted to the Hudson Street Hospital, delirious and suffering from rapidly repeated general convulsions. There were no localizing symptoms. He died within twenty-four hours after admission, and the autopsy disclosed the cyst as seen in the picture. No previous history of the case could be obtained. The patient was a Greek. The diagnosis of echinococcus cyst was made from the pathological examination of the tumor. Tumors of the brain occur both in children and adults with nearly equal frequency.

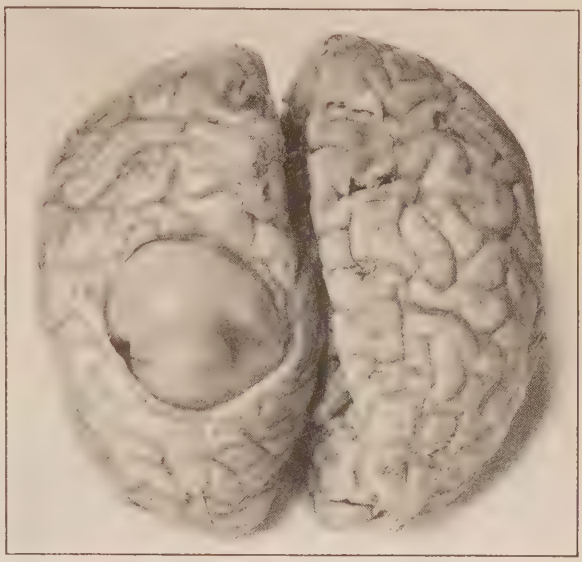


Fig. 153.—Echinococcus Cyst of the Brain. The specimen was obtained at autopsy in the House of Relief of the New York Hospital. The patient was brought to the hospital the evening before his death. He was stupid and soon began to suffer from general convulsions. In a few hours the stupor was followed by coma and the next day he died. The cyst of the brain was, of course, unsuspected until its presence was revealed upon opening the skull.

Sarcoma is the most frequent form in adults, tuberculous disease in children. Gumma is common in adults, but usually yields to specific treatment. Only a moderate number of brain tumors can be located by the symptoms. In some parts of the brain tumors produce no localizing symptoms, and in others localizing symptoms occur, but diagnostic errors are possible because tumors of the cortex or in the region of the basal ganglia may produce quite similar disturbances. In all cases of suspected brain tumor, syphilis must be sought for, and if the history is doubtful, active treatment for a number of weeks should be employed. In children especially, evidences of tuberculosis elsewhere point to a probability that the brain trouble is of the same character. In cases of metastatic carcinoma of the brain the primary tumor or the scar left after its removal will be evident. The sarcomata very rarely occur as secondary tumors in the brain. The parasitic cysts of the brain are of slower growth than the other forms of brain tumor, and very seldom give rise to any localizing symptoms, because they do not destroy the brain nor infiltrate it, but simply displace it. The symptoms, therefore, in these cases, will be general rather than local. In a certain proportion of cases of sarcoma and glioma there will be a history of injury to the head. In those cases of brain tumor which show marked variation in the intensity of the symptoms made under different conditions of circulatory activity and changes in the blood pressure, there is a probability that the tumor is of a vascular character—a vascular sarcoma or glioma.

Tumors may develop in any portion of the brain, and many of them, although easy to diagnosticate, are so situated as to be entirely beyond the reach of surgical interference. They are those, especially, which develop in the basal portion of the brain—the pons, the medulla, the several basal ganglia. They produce fairly definite symptoms, referable particularly to the functions of the cranial nerves. A considerable proportion of cerebral tumors, notably in children, develop in the cerebellum. The following group of symptoms are often present:

There will be *general symptoms* of disturbance of the brain—headache, vomiting, a change in the mental disposition, apathy or irritability, sometimes vertigo, the signs of optic neuritis, sometimes blindness, more rarely general convulsions. The headache may be referred to the back part of the head, or it may be a general headache, or be referred to the frontal region. Tenderness on percussion over the back part of the skull is present in many cases. The local symptoms of cerebellar tumor are giddiness and a staggering gait in walking. The staggering may occur away from or toward the affected side of the brain; the symptom indicates that the middle lobe of the cerebellum is involved. If symptoms of compression of one or more of the cranial nerves is present, it is probable that the site of the tumor corresponds with the side upon which the nerves are paralyzed. The tumors of the brain most accessible to operation, and whose exact location is most readily made out, are those situated in, or beneath, the cortex of the brain, in or near the motor areas. The symptoms produced by these tumors are general and local. The general symptoms consist, as in other brain tumors, of headache, vomiting, sometimes of changes in cerebration, choked disk.

The *local symptoms* consist sometimes of tenderness on percussion over the site of the tumor, sometimes in a local elevation of temperature in the same region. There are quite regularly localized muscular spasms of certain groups of muscles. The spasms are sometimes preceded, as in Jacksonian epilepsy, by subjective sensations of heat, cold, numbness, tingling, etc. At first these spasms occur in only one muscle, or in a limited group of muscles; the patient has a twitching of one eyelid, of the corner of the mouth, of a toe or finger. As the tumor grows larger and invades new portions of the brain, spasms of other groups of muscles will follow in regular order, until they may involve the muscles of the entire half of the body. During the occurrence of the convulsive movements, consciousness is not interfered with unless the tumor has reached a very considerable size. After the spasms have recurred for a certain length of time, the muscles become gradually or suddenly paralyzed, and subsequently contracted. When tumors develop in the occipital region they will be accompanied by hemianopsia; when they involve the sensory area in the parietal region, as well as the motor area, there will be sensory as well as motor disturbances. If they are upon the left side they may produce sensory aphasia or word blindness, or in the temporal lobe word deafness (Starr). It is, of course, impossible to discuss here

at length the various localizing symptoms which may occur in tumors of the brain.

Epilepsy.—Jacksonian epilepsy is caused by some focus of irritation in the motor area of the brain. The attacks begin with a sensation of heat, cold, tingling, or numbness in some particular part of the body, followed by spasmodic muscular contractions in the same area; thence the sensations and contractions spread in a definite order to other groups of muscles, and are followed by fatigue and weakness of these muscles. There may be partial loss of sensation lasting for several hours in the same regions as showed the spasms. The patient may lose consciousness if the spasms end in a general convulsion. A sensory equivalent of the spasms may occur when other areas of the brain are irritated. Thus sights, sounds, smells, or tastes may be perceived at the beginning of the attack, indicating irritation of the occipital region, or of the temporal region, or of the temporo-sphenoidal region, respectively. Sometimes the attacks begin with a spasm of the muscles of the right side of the face, and are accompanied or followed by motor aphasia. In these cases the irritation is situated in the third frontal convolution upon the left side of the brain. There are also psychical attacks attended by mania or stupor which are the equivalent of the other forms, the irritative lesion being situated in the frontal lobes of the brain.

Very varied lesions of the brain may cause epilepsy—sometimes of the ordinary idiopathic type, with general convulsions and unconsciousness, sometimes of the Jacksonian type just described. Thus, fractures of the skull, with depression or splintering, and the lodgment of fragments of the inner table in the brain; inflammation of the dura, of any origin—syphilitic, tubercular, or traumatic, the presence of a tumor in the motor area of the cortex; small hemorrhages into the cortex; small areas of sclerosis or of softening, and other lesions. When Jacksonian epilepsy follows injury, the site of the wound or fracture, with or without depression, may correspond with the localizing symptoms or it may not. If the site of the injury and the localizing symptoms correspond, the point at which the skull should be opened to reach the source of irritation is evident. If they do not, Starr believes, from conclusions based upon experience, that the localizing symptoms are a better guide to operation than the site of the injury. If the brain is exposed and no lesion is found, the area whence the irritation is supposed to proceed may be identified by touching various points of the cerebral surface with delicate electrodes bearing a mild Faradic current, until the muscles in which the spasms begin during an attack are caused to contract.

Hydrocephalus.—An accumulation of watery fluid in the interior of the skull may occur, very rarely, between the brain and its membranes; that is, between the dura and the brain. When *congenital*, and due to imperfect development of the brain, the children do not long survive. In the *acquired* form the condition may occur in children and in adults from atrophy of the brain, as a rare condition following wasting diseases. *Localized* accumulations

of serous fluid may occur in adults beneath the dura, as the result of chronic inflammation. *Hydrocephalus of the ventricles* of the brain is a common disease, and either congenital or acquired. The *acquired* form is usually developed during the early years of life; the *congenital* form is usually due to imperfect development of the brain. The watery fluid occupies chiefly the lateral ventricles. In the acquired form the condition may be due to inflammation, usually tubercular, of the lining of the ventricles, or to interference with the venous circulation in the veins of Galen by a tumor or other cause.

The diagnosis of *congenital* hydrocephalus is to be made by observing an abnormal increase in the size of the head, by unusual size of the fontanelles, and the imperfect union of the sutures of the skull. The development of the intelligence of these children is slow or imperfect. They learn to speak with difficulty, or not at all. The contrast between the enlarged and overhanging skull and the small face is very striking. Blindness and various mental symptoms develop during the course of the disease. When hydrocephalus develops after the skull has become ossified, the enlargement of the head is wanting and the symptoms are rather those of a tumor of the brain—headache, blindness, vomiting, squint, mental dullness, etc. Congenital hydrocephalus frequently accompanies rachitis.

Hernia cerebri—Cephalocele.—Prolapse of the brain following traumatisms has already been spoken of. The congenital forms occur as the result of imperfect development of the skull, such that the bony covering of the brain is wanting in certain situations, and through these gaps portions of the contents of the cranium protrude. These herniæ occur in the occipital region; at the root of the nose; rarely in the parietal region and in the region of the large fontanelle. Still more rarely they may occur in the base of the skull, and protrude into the cavity of the nose or into the throat, or even through a cleft palate into the mouth, or through the orbital fissure into the orbit, or into the spheno-maxillary fossa. They may contain the membranes of the brain merely (*meningocele*), or the brain and its membranes (*encephalocele*), or the brain and its membranes inclosing a cavity dilated into a sac filled with fluid communicating with one of the lateral ventricles of the brain (*hydrencephalocele*).

Many of these congenital herniæ are associated with a high grade of deformity of skull and imperfect development of the brain. The children are often born dead, or die soon after birth. This is particularly true of the cases of hydrencephalocele. Those who survive for any length of time are idiots, or more or less imbecile or feeble-minded. The herniæ vary much in size and shape; they may be very small and hardly noticeable, or as large as a child's head and sessile or pedunculated. The tumor may form a single rounded or ovoid mass, or be more or less lobulated or divided into several partly separate sacs. The tumors are usually compressible; if they contain much fluid they are translucent; they may show cerebral pulsation. Firm pressure upon the tumor causes it to diminish in size, sometimes with the production of cerebral symptoms—slowing of the pulse, vomiting, muscular spasms—occasionally un-

consciousness. It is sometimes possible to feel the border of the orifice in the skull after the tumor has been partly reduced. When the patient cries or coughs the sac is increased in size; during sleep it becomes smaller.

Varieties of Hernia cerebri.—The *meningoceles* occur most often in the occipital region, and protrude below or above the tentorium cerebelli. They

Fig. 154.—Meningocele. The infant shown in Figs. 154 and 155 was a patient in the service of Dr. Lewis A. Stimson in the New York Hospital. The large translucent tumor was connected with the interior of the skull but did not appear to contain any brain tissue. When pressed upon slight symptoms of compression of the brain could be produced. The child did not long survive.

sometimes occur upon the front of the head. The brain may be normal or the condition may be associated with hydrocephalus and imperfect development of the brain and an abnormally small skull—*microcephalus*. The children may

Fig. 155.—Meningocele.

be idiots; a good many of them die soon after birth or during infancy; occasionally they live to grow up. The meningoceles usually form smooth tumors covered by thinned integument. They are translucent; they fluctuate; they may be quite tense or only partly filled with fluid. They may be entirely re-

ducible; they seldom pulsate. Symptoms of cerebral compression may occur from pressure upon the tumor, as already noted.

The *encephaloceles* are more common than meningoceles; they contain a certain amount of brain substance, which is connected by a pedicle with the brain inside the skull. They may be solid, or contain a cavity which communicates through a canal with the lateral ventricle—*hydrencephalocele*. The encephaloceles occur more often in the front part of the skull than in the occipital region. They form tumors of small or moderate size; they pulsate more markedly, as a rule, than do the meningoceles, and show similar signs and symptoms when compressed. They increase in size during crying and coughing, and diminish in size during sleep. If the dural sac contains much fluid, they will be translucent. When a considerable portion of the brain lies external to the skull, the children are usually born dead or die soon after birth. If they survive for any length of time they are usually idiots; the skull remains small and undeveloped. If but a small protrusion is present the children may survive, and may even grow up to be persons of at least partly normal development.

Diagnosis.—In the diagnosis of these conditions the main points are that they are congenital tumors, plainly communicating with the interior of the skull, as described, and often associated with microcephalus. Those in the occipital region are usually *meningoceles*. Those containing brain substance are more often found at the root of the nose than in the occipital region. The *hydrencephaloceles* are more common than meningoceles, and occur also chiefly in the occipital region. They are generally rather large tumors; they fluctuate, are often translucent; they are not reducible, but diminish somewhat in size upon pressure. The skull, in most instances, is otherwise deformed. The *encephaloceles* are usually small tumors, and may be even met with in adult life. They are commonly situated in the front of the skull; they are not completely reducible; they pulsate, and increase in size on coughing, etc., and diminish during sleep.

By viewing the hernia by transmitted light it may be possible to see less translucent portions representing brain tissue. An X-ray picture may sometimes show the extent of the orifice in the skull. The greater the proportion of the brain lying outside the skull the less these cases are suitable for operation. The meningoceles with a narrow pedicle are most favorable. When associated with microcephalus, hydrocephalus, idiocy, or combined with defects in the cervical vertebræ, etc., they are better let alone.

INJURIES AND DISEASES OF THE FRONTAL SINUS

Injuries of the Frontal Sinus.—Wounds of the forehead, associated with fractures of the anterior wall of the frontal sinus by direct violence, are open to inspection and present no difficulties of diagnosis. Subcutaneous fractures, associated with laceration of the mucous membrane lining the sinus, are usually followed by subcutaneous emphysema of the forehead and eyelids, recognizable

by crackling and palpation. The emphysema is increased by sneezing, and by expiratory efforts when the mouth and nose are closed. Pain and local tenderness are present, and depression may be recognizable on palpation.

Acute Catarrhal Inflammation of the Frontal Sinus.—Acute catarrhal inflammation of the frontal sinus, complicating acute coryza, causes frontal headache, sometimes tenderness over the sinus.

Mechanical Closure of the Outlet to the Nose.—As the result of chronic inflammation, a hematoma, or the growth of tumors, the outlet from the sinus may be plugged, and the accumulated serous, mucous, or purulent exudate may cause gradually dilatation of the sinus wall, generally in the direction of the orbit. The eye may thus be displaced downward and outward.

Empyema of the Frontal Sinus.—Empyema of the frontal sinus occurs as an extension from inflammations of the mucous membrane of the nose; from infected fractures of its wall; from septic, tubercular, or syphilitic diseases of bone; from the growth of tumors; the presence of foreign bodies, and of the larvæ of insects. The inflammation may be acute or chronic. The symptoms of acute purulent inflammation are fever, local pain (often referred to the distribution of the supra-orbital nerve), tenderness and swelling of the forehead, and a purulent discharge from the nose. If the outlet through the infundibulum to the nose is plugged, the pain will be more severe. The obstruction may be overcome from time to time with the escape of a quantity of pus from the nose on sneezing and coughing. The wall of the sinus may gradually be dilated, producing deformity, or perforation may take place into the nose, the orbit, the forehead, or into the interior of the skull, with fatal meningitis. Rupture into the orbit is followed by a retrobulbar abscess or phlegmon, with exophthalmos, double vision, ptosis, blindness. Softening and perforation of the anterior wall of the sinus may lead to an abscess, or to pneumatocele capitis, as already described. In acute cases, perforation anteriorly will be accompanied by pain, tenderness, redness, and edema of the forehead and eyelids, and severe frontal headache. The septic symptoms will, of course, vary much in intensity in different cases.

Tumors of the Frontal Sinus.—The several forms of polypi—mucous, fibrous, and mucous cysts—occur in the frontal sinus, sometimes associated with similar growths in the nose. If they close the infundibulum they will produce the symptoms of catarrh of the sinus, sometimes with dilatation, as described. Osteoma is the most frequent tumor. It is of slow growth, and causes in time symptoms of irritation or of catarrh, frontal headache or neuralgia, the signs of acute inflammation being absent; later, distention and deformity. As already stated, these tumors originate as cartilaginous tumors in the ethmoid bone, and grow into the frontal sinus or the nose or into the orbit. These tumors may sometimes grow to a large size, causing deformities, notably displacement of the eyeball and interference with vision. Supra-orbital neuralgias, of greater or less severity, may occur from pressure. If they grow into the anterior fossa of the skull they may rarely produce pressure symptoms.

The pedicle of these osteomata may undergo atrophy or fracture, and they then exist as foreign bodies. These bony tumors are to be recognized by their slow growth and bony hardness. When exposed in the cavity of the sinus they are covered with mucous membrane, and thus resemble a polypus in appearance. Carcinoma may occasionally arise from the wall of the frontal sinus; in mode of growth and destructiveness it does not differ from carcinoma elsewhere.

CHAPTER XV

INJURIES AND DISEASES OF THE FACE

CONGENITAL DEFECTS

Harelip.—The deformity of harelip is so well known as to need no description. I will merely enumerate the different forms and grades of the condition. The cleft in the lip lies to one side of the median line: it may be single or double, and varies in extent from a slight furrow to a cleft running up to and through the nostril, involving the alveolar border of the jaw, when it is often combined with median fissure of the hard palate, or of the soft palate as well. In double harelip, intermaxillary bones form a more or less prominent projection attached to the vomer, and frequently are tilted upward and forward beneath the nose.

FIG. 156.—DOUBLE HARELIP IN AN INFANT. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

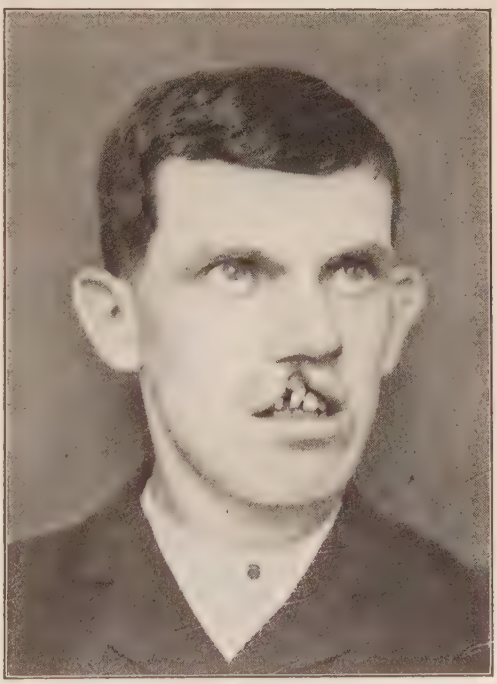


FIG. 157.—SINGLE HARELIP IN AN ADULT. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

Cleft Palate.—The fissures of the hard palate occur alone, or with harelip and fissures of the alveolar border. In cases of double cleft palate the vomer

remains ununited to the palate, and presents as a central diaphragm when viewed from the mouth. Central fissures of the soft palate occur alone, or combined with fissures of the hard palate. In some cases of harelip and cleft palate the intermaxillary bones are not developed, and a broad space is thus left beneath the nose. Such deformities are sometimes associated with imperfect development of the brain.

Rare Congenital Defects.—Other rarer forms of congenital defects are complete or partial median cleft of the lower lip, sometimes combined with a furrow between each nostril and the bridge of the nose. This is the so-called "*dog-nose*" deformity. There are also cases of median fissure of the nose, and of congenital absence of the nose; of congenital fistula in the center of the upper lip; of lateral fissures of the upper lip running up toward the eye —or even upon the forehead; such fissures may be bilateral. Unilateral or bilateral fissures running outward from the corners of the mouth have been observed, producing "*macrostoma*." The mouth may also be abnormally small. Fissures of the lower lip are very rare; a few cases have been reported. The fissures may involve the median line of the lip only, or include the lower jaw, or the tongue as well—so that the cleft extends nearly, or quite, to the hyoid bone. There are also unilateral or bilateral incomplete fistulæ of the lower lip.

Fig. 158.—Harelip and Cleft Palate in an Adult. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

A variety of congenital abnormalities have been observed of the *external ear*. The ear may be unduly large, or small, or absent. The external auditory canal may be closed or absent. Congenital auricular appendages occur as small fleshy nodular growths, sometimes containing cartilage, usually in front of the tragus. Congenital absence of the *tongue* has been observed. The congenital deformities of the lower jaw are several; the jaw may be too small, one side may be larger than the other, or the jaw may be double. The entire half of the face may be notably smaller on one side than the other. Hypertrophy of one half of the face is much less common.

INJURIES OF THE FACE

Contusions of the face are followed, where the tissues are loose, notably in the eyelids, by the well-known ecchymotic discoloration "black eye." Contused wounds made against sharp bony prominences, such as the edge of the orbit, may resemble incised wounds more or less closely.

Wounds of branches of the fifth pair of cranial nerves are not commonly followed by permanent paralysis of sensation; complete or partial union and regeneration is the rule. A painful neurofibroma may, very rarely, form upon the cut end of the nerve. The nerve may be included in a scar and cause neuralgia. (See also Injuries of Nerves.)

Division of the levator palpebræ muscle within the orbit may be followed by retraction of the muscle and permanent ptosis—unless sutured. Severe *incised* as well as *contused* and *lacerated wounds* of the face, if infected, are occasionally followed by secondary hemorrhage. I once saw a nearly fatal secondary hemorrhage from the facial artery in an infected incised wound of the cheek.

Gunshot Wounds of the Face.—Gunshot wounds of the face are nearly always accompanied by injuries of the bone. Great destruction of the bones and soft parts are produced by shotgun wounds at close range, and, in time of war, by large projectiles or portions of exploded shells; also by dynamite and other explosions. Small shot, spent bullets, and bullets from small pistols may fail to penetrate the bone, and flatten against it. Suicides who place the muzzle of a pistol in the mouth and close the lips upon it suffer injuries in which an explosive action is marked. The soft parts are burned; linear tears may proceed in a radiating manner from the mouth, through the lips and cheeks; and these tears have often clean-cut edges. The injuries are fatal, as a rule, when the shot penetrates the base of the skull and the brain. If the pistol is pointed too far forward, because the individual bends his head too far backward, the bullet may emerge at the root of the nose. A similar experiment with a high-powered rifle literally blows the top of the head off.

The gunshot wounds of the mouth and face are attended by three dangers, especially (injuries of the brain excepted): they are hemorrhage, from the wounding of large vessels; asphyxia; aspiration-pneumonia. The asphyxia may be caused, immediately, by blood flowing into the trachea; by paralysis of the tongue, such that it falls back and closes the larynx, when the muscles which hold it forward are destroyed, or subsequently, by inflammatory swelling, causing mechanical closure of the throat or edema of the glottis. The danger of asphyxia immediately after the injury will produce very definite symptoms, and a suspicion that asphyxia is threatened may be entertained when the patient begins to complain of difficulty in swallowing or in breathing.

Wounds of the Face.—Wounds of the face are frequent injuries—incised, contused, and gunshot wounds, all are common. They bleed freely. Division of the facial or of the temporal artery, superficial or deep, may be followed by fatal bleeding. The facial nerve, Steno's duct, the eyeball, the tear duct,

may be wounded. The anatomical situation of the wound and the accompanying symptoms—bleeding, facial paralysis, a salivary fistula, or the escape of saliva from the wound, disturbances of vision, etc.—suffice for the diagnosis. A divided tear duct usually heals without trouble. In gunshot and stab or punctured wounds of the face, the various bony cavities, including the brain, may be wounded, and the bullet, or a portion of the vulnerating instrument, may remain in the wound. Such foreign bodies may heal in the wound or cause suppuration—if in the brain, usually with fatal results. Their locality, if of metal, can usually be detected with the X-rays. The vitality and blood supply of the face is so great that wounds of this region heal quickly and well—better, in fact, than in any other region. Even extensive contused and lacerated wounds, if carefully cleaned, heal with very little trouble. Powder stains upon the face are common after self-inflicted gunshot wounds. The grains of black powder embedded in the skin remain as permanent blue stains. Smokeless powder leaves no such stain. (See Gunshot Wounds, General Surgery.)

FIG. 159.—SCARS AND DEFORMITY FOLLOWING EXTENSIVE BURNS OF THE FACE PRODUCED BY THE EXPLOSION OF GAS IN A COAL MINE. The upper eyelids in this case were almost totally destroyed and the lower lip was drawn downward away from the gums and teeth. The eversion of the lower lids is well shown. At the time this photograph was taken several plastic operations had been done for the restoration of the upper lids and for the relief of the deformity of the mouth. Before the deformities were all repaired eleven operations were done by Dr. Charles McBurney.

TETANUS.—Tetanus may follow wounds of the face. (See Tetanus.)

Burning of the Face.—Burning of the face occurs from hot fluids, from steam, from flame, from explosions of gunpowder, or of gas in mines, or from caustic chemicals—nitric, sulphuric acids, caustic potash, etc. (The appearances produced by chemicals have been described in the chapters on General Surgery.) The erythema of burns of the first degree is often caused by undue exposure to hot sunlight (sunburn); the appearances are well known to everyone. Burns of the second degree, with the production of blebs, are caused by the momentary action of steam, hot liquids, or flame. Owing to the automatic closure of the eyelids, the eyeball usually escapes injury. When the individual is wrapped in flames—as from light clothing catching fire—extensive burns of the trunk and extremities usually occur, imperiling life, and the burn of the face is a minor part of the

injury. Epileptics and others who become unconscious may fall upon a hot stove, or the like, and receive localized deep burns of the face. Prolonged exposure to steam, flame, etc., the caustic acids and alkalis, and powder and other explosions, usually produce deep burns with the formation of eschars. The eyes may be destroyed, and the sloughs may extend to or involve the bones.

The principal interest attaching to these burns lies in the danger of infection during the separation of the sloughs, and in the scars which are left behind. The subsequent contraction of such scars produces deformities, such as eversion of the lower eyelid (ectropion). Partial destruction of the upper lid, and inability to close the eye and properly cover the cornea, lead to ulceration of the cornea. Eversion of the lower lip follows burns of the lip and chin. The mouth may be drawn to one side, or the size of the orifice may be diminished, or the chin may be drawn downward toward the sternum, the nostrils may be deformed or closed. Deep scars upon the cheeks may lock the lower jaw, so that the teeth cannot be properly separated, etc.

Freezing of the Face.—Exposure to extreme cold may freeze portions of the face; the tip of the nose and the upper rim of the ear are the parts most commonly frozen, less often the cheeks. Some loss of substance may follow. Partial frostbite may render the nose and ears unduly sensitive to cold for some time. The tip of the nose may be left in a more or less chronic state of congestion and redness; or chilblains—a tendency to swelling, and redness of the part after slight chilling—may remain for some time.

DISEASES OF THE FACE

Furuncle and Carbuncle of the Face.—Furuncle occurs upon the face, notably upon the upper lip, the tip and filtrum of the nose, less often on the cheeks. The signs and symptoms do not differ from those of furuncle elsewhere, except that here they are quite painful and very tender. Carbuncle of the lip consists of a congeries of furuncles. The whole thickness of the lip may be infiltrated and converted into a dense brawny mass of infected tissue, the pain is marked, and the constitutional symptoms are severe. In bad cases the condition may cause death by acute sepsis, or by thrombophlebitis, extending from the angular vein into the ophthalmic vein, and thus into the cavernous sinus, with pyemia and meningitis; or downward, through the facial vein, into the internal jugular. The course of the thrombophlebitis can sometimes be made out by finding a cordlike mass of infiltration in the course of the vein. Edema and infiltration of the eyelids point to phlebitis in the orbit; infiltration in the submaxillary region, to infection through the facial vein.

In these cases a rapidly progressive septic phlegmon of the tissues of the face and neck may begin as such, under stormy symptoms of local pain, tenderness, and swelling, or an ordinary acne pustule, furuncle, or carbuncle, may suddenly assume a malignant form. The pus-producing organisms, usually Staphylococcus pyogenes aureus, or, less often, Pyogenes albus, are the cause

of the infection. The condition is commonly spoken of as malignant pustule of the lip, but has no relation to true malignant pustule (anthrax). Depressed conditions of health, notably diabetes, favor the occurrence of these malignant infections. Local conditions favoring the occurrence of furuncle and carbuncle are a dirty skin, eczema, sycosis, and acne of the face. The infection is often caused by scratching with dirty finger nails, infected perhaps from handling other purulent foci.

Anthrax of the Face.—Anthrax occurs chiefly among those who handle the hides, the bodies, or the feces of infected animals. The infected fingers carry the bacilli to some minute abrasion on the face. It is believed that the bites of infected flies may transmit anthrax. The pustule occurs upon the face in nearly one third of all cases. In from twenty-four hours to five or six days after infection, a red papule appears at the site of inoculation, accompanied by intense itching. In a few hours a vesicle appears on the papule; the swelling and redness spread superficially and deeply. The vesicle bursts and discharges a little blood-stained fluid containing many anthrax bacilli, leaving behind a depressed ulcer, the base of which rapidly dries into *a black crust*; an intensely red, hard area of infiltration surrounds the pustule. Upon the surface of the area a circular row of secondary vesicles appear; there is added edema of the neighboring tissues and enlargement of the lymphatic glands. The necrotic area of the pustule may increase to the size of a silver dime, or of a twenty-five-cent piece, sometimes larger.

The cases may be divided into two groups: those in which the bacilli remain localized in the pustule, and those in which they are disseminated rapidly in the subcutaneous tissues, with the production of a progressive brawny edema, which advances in all directions, and is accompanied by profound constitutional symptoms, and final dissemination of the disease through the blood-vessels, with fatal infection of the entire organism, as already described in the section on Anthrax. (See Anthrax, General Surgery.) The localized cases may remain with few or no constitutional symptoms for many days. The process may then proceed to healing with the death of the bacilli, or dissemination may finally take place. The diagnosis is established readily enough by the history, by the character of the pustule, by finding the bacilli in the discharge, or in scrapings from the base of the pustule, or in sections of the excised pustule, or by inoculating a mouse. It is worth remembering that not every pustule with a black crust which appears upon the face is anthrax. A very similar appearance to an anthrax pustule in its early stages, before the formation of secondary vesicles, may be caused by Staphylococcus pyogenes aureus.

Glanders.—Glanders has already been described in a separate section. In man, the infection takes place through minute wounds or abrasions, usually of the hands and face. The pustules of the face occur upon the general integument, upon the mucous membrane of the nose, the mouth, and the conjunctiva. As already noted, the glanders pustules begin as nodular inflammatory infil-

trations, which break down, and may undergo a rapid and destructive ulceration; diffuse phlegmonous infiltrations may also occur resembling phlegmonous erysipelas. (For further information, see section on Glanders.)

Actinomycosis of the Face. (See Actinomycosis.) **Erysipelas of the Face.** (See Erysipelas.) **Lupus of the Face.** (See Lupus.) **Noma of the Face.** (See Noma.)

Syphilis of the Face.—As already noted, the lower lip is a frequent site for the *initial lesion* of syphilis. A history of the source of infection may often be obtained. After the period of incubation is passed *chancre* of the lip develops as a somewhat indurated or elastic nodule, which slowly increases in size, is painless and insensitive, nearly always ulcerates, leaving a superficial, round, or oval, raw surface, of the characteristic ham-colored, moist character. The surface bleeds readily, and often becomes covered by a yellowish crust. Enlargement and induration of the submental and submaxillary lymph glands appears during the first week or two. These glands often reach a considerable size; they are painless and insensitive, rarely suppurate. From carcinoma of the lip, chancre can usually be differentiated by the age of the patient, by the fact that chancre, after reaching a certain size, ceases to extend; whereas, cancer advances continually. In cases of doubt, a microscopic examination of a small portion of the infiltrated tissue will make the diagnosis clear.

FIG. 160.—NOMA, GANGRENE OF THE CHEEK AND LIPS. The child was ten years of age and was brought to the hospital with a gangrenous lesion fully developed, as shown in the photograph. The entire thickness of the cheek was necrotic, and during the twenty-four hours which intervened before the patient's death the gangrenous process spread rapidly. Extreme constitutional depression existed so that no operative procedures were possible. The child was stupid and did not seem to suffer pain. She died about four hours after the photograph was taken. No special cause could be learned for the occurrence of the lesion. (Author's collection.)

The *secondary lesions of syphilis—papular and pustular eruptions*—occur especially on the forehead along the border of the hair, upon the cheeks near the nose, and elsewhere. Their characteristic appearances and arrangement are described under Syphilis, as well as those of the papules upon the mucous membrane of the mouth, lips, tongue, and pharynx, commonly known as *mucous patches*. These form one of the most constant and characteristic

lesions of the disease, and are usually found at some period during the secondary stage.

The *tertiary lesions of syphilis—gummata* of the soft parts of the bones—are frequent upon the face, both in the acquired and hereditary forms of the disease. Gumma is recognized here, as elsewhere, by the punched-out appearance of the ulcers; the induration of the border of the ulcer, characteristic of cancer, is wanting. The base of the ulcer consists of adherent necrotic tissue, the edges are undermined. When progressive, the ulceration is more rapid than in cancer. Certain forms of gummatous ulceration upon the lips, cheeks, and nose resemble epithelioma to some extent. Large doses of iodid cause these ulcers to heal. A fragment of tissue may be removed and examined microscopically.

FIG. 161*a*.—DERMOID CYST OF THE SEPTUM OF THE NOSE. (Collection of Dr. Ellsworth Eliot.)

FIG. 161*b*.—RESULT OF OPERATION IN DR. ELIOT'S CASE OF DERMOID CYST OF THE NOSE.

It happens sometimes that chronic syphilitic ulcers may become the seat of cancer. Characteristic round white scars are often present in syphilis, on the face, the shins, and elsewhere. In tertiary syphilis the secondary enlargement of lymph nodes, present in cancer, are usually wanting. The bones of the nose, and the hard and soft palate, are often attacked by syphilis. As pointed out in another place, the syphilitic nose with sunken bridge is characteristic. A nose destroyed by lupus looks as though it had been shaved off, the destruction affecting the soft parts chiefly. The necrotic processes of syphilis attacking the nasal septum, palate, etc., often begin quite insidiously with the symptoms of nasal catarrh. As soon as ulceration of the mucous membrane establishes communication with the necrotic bone, the stinking putrid odor of the breath becomes characteristic.

Gummata of the face in hereditary syphilis sometimes produce most hideous deformities with destruction of the features, and subsequent contraction of scar

tissue, such that the disfigurement is of an indescribably horrible character. Deep-seated gummata of the face, notably those connected with the jaws and the masseter muscles, etc., may form solid tumors of considerable size, and unless they soften, discolor the skin and ulcerate, may simulate malignant growths or actinomycosis. In cases of doubt, active mercurialization and the use of the iodids, together with search for other signs of syphilis, will help the diagnosis.

TUMORS OF THE FACE

Lipoma.—I have already spoken of lipoma of the forehead. Lipomata may also rarely occur in the parotid region and upon the chin. They occur, rarely, as subcutaneous or submucous tumors in the lips and eyelids, and upon the bridge of the nose. The deep lipoma of the cheek may present more prominently in the mucous membrane of the mouth, or upon the cheek, in the neighborhood of the anterior border of the masseter muscle. Combinations with fibroma and angioma may occur. Inasmuch as the lobulated structure of lipoma is sometimes wanting, the diagnosis is not always easy; they are often taken for dermoids, or mucous cysts, or even for chronic abscesses. The very slow growth, puncture with an aspirating needle, and, finally, incision, may be necessary for a diagnosis.

Fig. 162.—Congenital Mixed Lymph and Venous Angioma of the Face, Inoperable. (New York Hospital collection.)

Fibroma.—Both hard and soft fibromata occur upon the face. Of the hard form, *keloid* is the most common; it frequently develops in the lobule of the ear, in the scar left after boring the lobule for earrings. The tumors are of small size, firm, painless, and insensitive, of slow growth, and of a pink or red color. They may appear elsewhere on the face in the scars of wounds. The soft fibroma occurs upon the face in the form of fibroma molluscum (Cutis pendula), as single or multiple tumors, of slow growth, which may reach in time a very large size and produce large, soft, pendulous masses, covered

by loose, flabby skin, which hang down in folds, causing peculiar and characteristic deformities. These fibromata also occur in combination with neurofibroma, plexiform neuroma. In these cases the bundles of enlarged and thickened nerves can sometimes be felt subcutaneously in the tumor mass like a bundle of angleworms. Combinations also occur with angioma, lymphangioma, and myxoma. Some of the hairy and pigmented moles are soft fibromata or combinations of fibroma with angioma. The congenital enlargements of the upper and lower lip are fibromata in combination with lymphangioma and angioma (macrochelia). (See Tumors.)

Sarcoma.—The majority of sarcomata occurring in the face have their origin in bone. The sarcomata of the soft parts originate, not infrequently, in pigmented moles or nevi, and are then, as a rule, of the melanotic type. As described under Tumors, they are of rapid growth, and produce multiple pigmented tumors in the vicinity. Early dissemination with widespread metastasis is the rule.

FIG. 163.—CAVERNOUS LYMPHANGIOMA OF THE FACE, CONGENITAL. Child eighteen months old. The portion of the growth above the eye was removed by operation. The patient did not survive. (Collection of Dr. F. W. Murray.)

FIG. 164.—CONGENITAL LYMPHANGIOMA OF THE UPPER LIP (MACROCHEILIA) IN A LITTLE GIRL. (Collection of Dr. Charles McBurney.)

Lymphangioma.—Lymphangiomata, either *simple*, *cavernous*, or *cystic*, occur in the upper and lower lip and in the cheeks. Some of the cases of macrocheilia belong to this group. The lymphangioma simplex and lymphangioma cavernosa sometimes form diffuse tumors. The cystic lymphangioma are usually circumscribed. Combination forms also occur; they are often small, circumscribed, congenital tumors of the face and lips, which subsequently take on a slow growth, and may involve, in time, the greater portion or half of the

face. The skin over the tumor is normal and smooth, and being adherent, or forming a part of the growth, it does not wrinkle when the tumor is moved or compressed. They are soft and spongy tumors, which diminish in size on pressure. They are to be distinguished from hemangiomata by the blue or red color of the latter, the combination forms of lymphangiomata with hemangiomata, being pale pink, red, or light blue, according to the relative proportion of lymph and blood-vessels. Existing in combination with fibroma and lipoma, they give rise to tumors having the characters of cutis pendula, or elephantiasis of the face.

The *cystic lymphangioma* occur most often in the cheeks, and are congenital, or develop from the cavernous form. They give the characters of cystic tumors under no great tension, containing lymph. The skin, or mucous membrane, may be so thinned over them that they are plainly translucent. These angiomata often become infected through abrasions, etc. The infection gives rise to signs of inflammation in the tumor which lasts for a certain time, is followed by resolution or by suppuration. The attacks of inflammation may lead to an intermittent progressive enlargement of the growth. While the diagnosis is usually easy, they may be confounded with cystic tumors of the parotid gland, or with branchio-genetic cysts, and the diagnosis may only be made by microscopic examination. Mucous cysts of the mouth may occur immediately beneath the mucous membrane of the lip. Their contents are mucus, not lymph.

Acne Rosacea.—The highly developed forms of acne rosacea which are seen in elderly people and form a peculiar red knobby enlargement of the nose consist of an hypertrophy of the connective tissue, dilatation of the small blood-vessels, and hypertrophy, or cystic degeneration of the sebaceous glands. The orifices of the glandular organs of the skin are frequently dilated into pits, and give the enlargement a peculiar spongy appearance.

Angiomata of the Face.—The face is a favorite seat for angiomata. *Angioma simplex* occurs upon the face congenitally in the well-known form of *nevus*. The tumors form larger or smaller, flat, moderately elevated, or, more rarely, prominent and lobulated, pink, red, or purple red, soft tumors upon the skin of the face, the forehead, the eyelids, the nose, the lips, the chin. The spot may be no larger, or scarcely larger, than a flea bite, at birth, and may remain stationary, or grow quite rapidly during the first years of life, so that it involves a considerable portion of the face. They are often pigmented, and sometimes are covered with an abundant growth of fine soft hair. They are popularly believed to arise from maternal impressions. Many of these tumors are of considerable size at birth, and only slowly increase with the growth of the individual. Sometimes the angiomata begin in the subcutaneous tissues, and only reach the skin after some time, so that there may gradually appear over the surface, here and there, faintly red or blue spots, which increase in size and color when the child cries. Later on, these tumors

may grow outward and form red or blue lobulated masses. Such tumors occur most often on the eyelids, lips, cheeks, and nose.

FIG. 165.—CONGENITAL ANGIOMA OF THE EAR. (Collection of Dr. Charles McBurney.)

The *cavernous angioma* of the face occurs especially upon the lips, and often forms tumors of considerable size involving the whole thickness of the lip and forming spongy, soft blue masses. They swell with the increase of venous pressure in crying, coughing, etc., and diminish in size when compressed between the fingers. They are sometimes painful. They may gradually grow, and occupy a considerable portion of the face and neck. The *arterial angiomata* have been spoken of under the head of Cirsoid Aneurism.

FIG. 166.—RAPIDLY GROWING AND MALIGNANT FORM OF EPITHELIOMA OF THE CHEEK. (Collection of Dr. Charles McBurney.)

Epithelial Tumors of the Face.—Epithelial tumors of the face occur in both benign and malignant forms. Among the benign tumors are *horns*. They occur most often upon the forehead, less often upon the lips and in other situations. Old women are usually affected. *Sebaceous cysts* occur upon the face much less often than upon the scalp. They occur in front of the ear, in the cheeks, in the lips. They do not reach so large a size

as upon the scalp, but possess the same clinical characters. *Warts* quite commonly occur upon the face in various forms, both hard and soft, sometimes pigmented and hairy. They may give rise to epithelioma, as has already been noted. Retention cysts in the hair follicles constitute the well-known "black heads," or *comedones*. Retention cysts of the sebaceous glands constitute the little white, pearly tumors not infrequently found upon the skin of the face (*milium*).

Adenoma of the Sweat Glands.—They form, according to the description of Stilling, small, slightly elevated, sharply circumscribed, nodular, or sausage-shaped elevations upon the skin. They develop slowly near the eye and the angle of the jaw in old people. They bear a certain clinical resemblance to lupus. *Adenomata of the sebaceous glands* occur in the eyelids and upon the nose. They form wartlike or knobby little tumors, varying in size from a pea to a walnut, and possess a true adenomatous structure. They are often multiple.

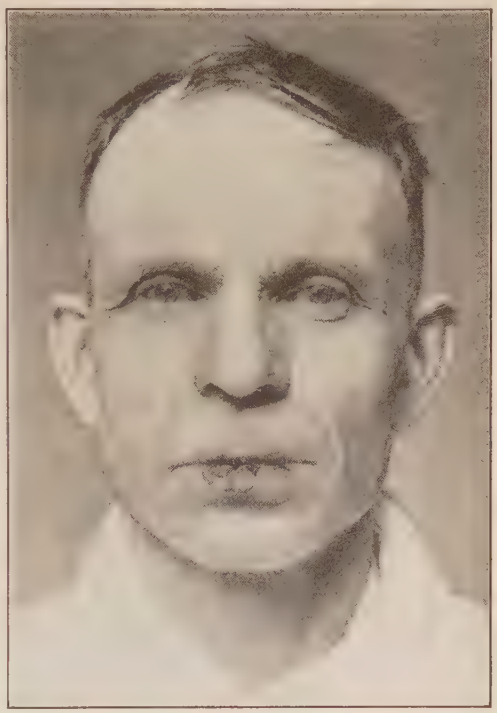


Fig. 167.—Early Stage of Epithelioma of the Lip. (Author's collection.)

Dermoid Cysts of the Face.—Dermoid cysts of the face occur, as already stated (Tumors of the Scalp), on the superior border of the orbit and at the root of the nose. They may also occur in the temporal region. They are to be distinguished from sebaceous cysts by the fact that they are frequently congenital, occur in special situations, grow very slowly, are seldom, if ever, larger than a walnut, are more deeply seated, often attached to the bone—sitting in a depression of the bony surface.

Carcinoma.—Skin carcinoma, or epithelioma, very frequently occurs upon the face, quite commonly at the junction of the skin with the mucous membrane; the red border of the lower lip and beneath the lower eyelid, the alæ of the nose, the cheeks, are all favorite sites. Epithelioma of the upper lip is a surgical curiosity. Chronic sources of irritation strongly predispose to the occurrence of cancer of the face. I have already referred to the fact that epithelioma of the lower lip nearly always appears in pipe-smokers. Any one of the benign forms of epithelioma already spoken of may become the seat of cancer. Warts, horns, hypertrophy, or disease of the glandular elements of

Fig. 168*a*.—Epithelioma of the Lower Lip. (Collection of Dr. Charles McBurney.)

to invade the deeper tissues, to infect the lymph nodes, and cause general carcinosis.

Flat Form of Carcinoma.—The flat form of carcinoma, already described under the head of Rodent Ulcer, presents itself as an indurated nodule, or larger, flat, slightly elevated area of infiltrated tissue which finally undergoes ulceration. The edges of the ulcer are slightly hard and elevated; the skin around the ulcer is often drawn into little wrinkles by cicatricial contraction. In the early stages the ulcer is covered by a crust; beneath the crust there accumulates a little purulent discharge. The spread of the ulcer is

the skin, sebaceous cysts, chronic skin diseases—eczema, psoriasis—repeated attacks of erysipelas, syphilitic or tubercular ulcerations, scars, chronic patches of seborrheic eczema, all may give rise to the development of cancer, and this list might be enlarged. The disease is one of advanced life, although it may occur rarely in young persons. I have seen an epithelioma of the lower lip in a man of twenty-eight years, and have recently operated upon another aged twenty-seven. Two forms are to be distinguished: the slowly growing, superficial form—flat carcinoma—and the more malignant form which tends rapidly

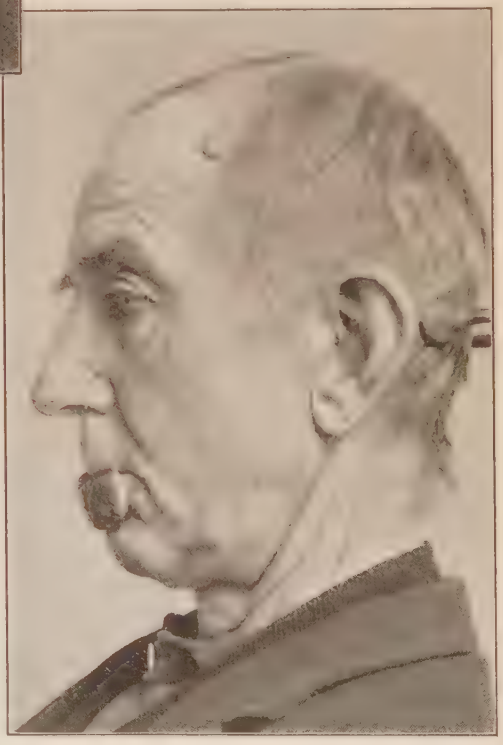


Fig. 168*b*.—Profile View of the Same Patient as Fig. 168*a*. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

usually very slow, and there is a tendency for the older portions to heal with marked cicatricial contraction. This form of epithelioma especially affects the forehead, the temple, the alæ of the nose, the eyelids, and the cheeks. It is sometimes curable by means of the X-rays and radium. The disease may spread superficially for many years, but after a time tends to invade and destroy the deeper structures (see Tumors). Infection of the lymph nodes occurs late or not at all.

Deep or Infiltrating Form of Carcinoma of the Face.—The deep or infiltrating form of carcinoma of the face has its especial home upon the lower lip; it is in every way a progressive, infectious, and surely fatal disease, unless removed by an early and thorough operation. It is one of the forms of carcinoma which is not cured by the X-rays. As occurring upon the lip, it is rare before forty years of age. There forms upon the red border of the lip—often just to one side of the median line, never, as far as I am aware, at the corner of the mouth, sometimes upon the site of a chronic fissure of the lip, or where the epithelial covering has become thickened or horny from chronic irritation—an indurated plaque, which soon develops into a nodule involving a considerable part or the whole thickness of the lip. The surface of the nodule soon breaks down and forms an ulcer with indurated base and borders. Upon the surface of the ulcer minute white points can sometimes be seen, and pressure may cause the extrusion of columns or nests of epithelial cells. Papillary outgrowths rarely occur in the epithelioma of the lip.

Fig. 169.—Epithelioma of the Lower Lip. (Author's collection.)

The progress of the disease is fairly rapid and the infiltrated and ulcerated areas may reach large dimensions in a few months. The lymphatic glands beneath the chin and in the submaxillary region soon become enlarged and hard. If the growth is not removed, the entire lip and chin, the mucous mem-

brane of the mouth, and the jaw are infiltrated. Ulceration in the interior of the mouth causes the breath to become offensive. The patient begins to suffer from chronic sepsis. The cancerous tumors of the neck increase in size, break down and ulcerate, and add to the miseries of the patient. Death occurs from chronic sepsis, from hemorrhage, from exhaustion, from aspiration pneumonia, from asphyxia, usually before metastases in internal organs have had time to destroy life.

INJURIES AND DISEASES OF THE ORBIT

Wounds of the Orbit.—Wounds of the orbit are interesting from the fact that they are sometimes accompanied by perforation of the wall of the orbit and injury of the brain. The gunshot and punctured wounds are particularly interesting in this connection. As the result of infected wounds of the orbit, or infectious processes originating in the orbit or in the vicinity, suppuration of the tissues of the orbit may take place, not infrequently with infection through the ophthalmic vein, sinus thrombosis, meningitis, and pyemia. The symptoms of *phlegmon of the orbit* are severe pain, fever, edema of the eyelids, swelling of the conjunctiva, exophthalmos, immobility of the eyeball, and diminution or loss of vision. Invasion of the interior of the skull is characterized by the symptoms described under appropriate headings. The presence of *foreign bodies* in the orbit, if metallic, can usually be located by means of the X-rays. For the injuries and diseases of the eyeball itself the reader is referred to special works on the topic.

As the result of wounds and fractures of the skull, an *arterio-venous aneurism* may develop between the cavernous sinus and the internal carotid artery. The signs and symptoms are as follows: There is exophthalmos; the eyeball pulsates, and the pulsation can be both seen and felt; the eyelids are swollen; there is often ectropion of the lower lid; pressure on the common carotid artery of that side stops the pulsation; vision may be normal or diminished. *Emphysema* of the loose tissues of the orbit occurs as the result of fractures, or perforations from disease, of the walls of the neighboring air-containing cavities, the frontal sinus, the antrum of Highmore, the ethmoid cells, fracture of the lacrymal bone. The symptoms are exophthalmos, usually emphysema of the eyelids, and more or less immobility of the eyeball, generally without impairment of vision.

Tumors of the Orbit.—Tumors of the orbit may arise in the eyeball itself, in the other tissues of the orbit, or from the neighboring cavities, notably the frontal sinus and the antrum. Several varieties of sarcoma originate in the eyeball, in the optic nerve, or in the other soft tissues of the orbit—gliosarcoma, melano-sarcoma, and other forms. These tumors are usually characterized by rapid growth and great malignancy. Generally speaking, rapidly growing, solid tumors of the orbit, which do not pulsate and have an uneven surface, do not contain fluid; of firm consistence, or more elastic, are sarcomata. Pul-

sating angiosarcomata also occur in this region. With the growth of the tumor there is a progressive exophthalmos, disturbances of vision, later blindness, involvement of the surrounding structures, perforation of the cranial cavity, etc. Echinococcus cyst has been observed in the orbit. The diagnosis must be made upon the recognition of a cystic tumor from which characteristic fluid is withdrawn. Dermoids are occasionally observed in the orbit. In melanosarcoma, primary in the choroid, about twenty-five per cent of cures are obtained if the eyeball is removed very early.

AFFECTIONS OF THE FIFTH AND SEVENTH PAIRS OF CRANIAL NERVES

Neuralgia of the Fifth Pair of Cranial Nerves.—The *symptoms* of neuralgia of the fifth pair of cranial nerves consist of pain in the distribution of one or more of the branches of the nerve. The pain may be continuous or intermittent. The attacks of pain are usually brought on by slight sources of external irritation, such as motion, pressure, a draught of cold air, or mental excitement. The motions of the jaws in eating may excite pain. In addition to the pain, there are sometimes associated spasmodic contractions of the muscles supplied by the facial nerve. Serious interference with the general health appears in chronic or severe cases. The characteristic feature of the attacks are their lightninglike suddenness and often agonizing severity. The duration of the attacks is variable—seconds, minutes, or hours.

The *causes* of these neuralgias are very various. They may be due to diseases of the brain, syphilis, the presence of tumors, or other intracranial diseases; they sometimes depend upon general conditions of the organism, such as autointoxication from constipation of the bowels, anemia, hysteria, chronic malarial poisoning, and other general states of depression. It is of course highly important to exclude such general causes before submitting a patient to surgical treatment. The *local causes* are inflammation of the sheath of the nerve itself, which may be due to local irritation or inflammation in the region of distribution of the nerve, such as diseases of the teeth and jaws, pressure upon the nerve by scars, inflammatory exudates, or tumors. It is not always possible to determine whether the neuralgia is of a central or peripheral origin. In seeking for a central cause it is necessary to exclude the local causes already mentioned, as well as the general diseases and conditions which may give rise to neuralgia. Accompanying cerebral symptoms, or the involvement of other nerves, would point to a central organic origin.

In determining the question of which branch of the nerve is at fault, the history is important. In the early stages of the disease the pain may have been confined to but one branch, and only have involved the other branches of the nerve at a later period. Sometimes there exist painful points; for example, pressure upon the supra-orbital nerve at its exit from the orbit, upon the infra-orbital nerve at the infra-orbital foramen, or upon the mental nerve at the side of the chin may always give rise to an attack. On the other hand, the patient

may not be able to localize the pain in one particular branch. Sometimes that branch of the nerve in which the trouble has originated remains tender between the attacks of pain. In some cases pressure upon the nerve which was the original seat of the disease will cause diminution of the pain. During the attacks of pain there occur vasomotor and trophic disturbances, redness of the conjunctiva, an increased secretion of tears, nasal mucus, and saliva. Sometimes flushing of the face, a sensation of warmth, and an increase of perspiration. Sometimes herpes vesicles develop in the distribution of the nerve, notably upon the forehead.

In attempting to locate the cause of the trouble in one particular branch of the nerve it is necessary to remember that a primarily local cause may have produced a neuritis which has spread and become central. The more completely all three branches of the nerve are involved in the neuralgia the more likely that the disease can only be relieved radically by an operation upon the ganglion. The fact that but a single branch of the nerve is involved does not necessarily mean that the neuralgia is of peripheral origin. An intracranial irritation or pressure may be limited to a single branch of the nerve.

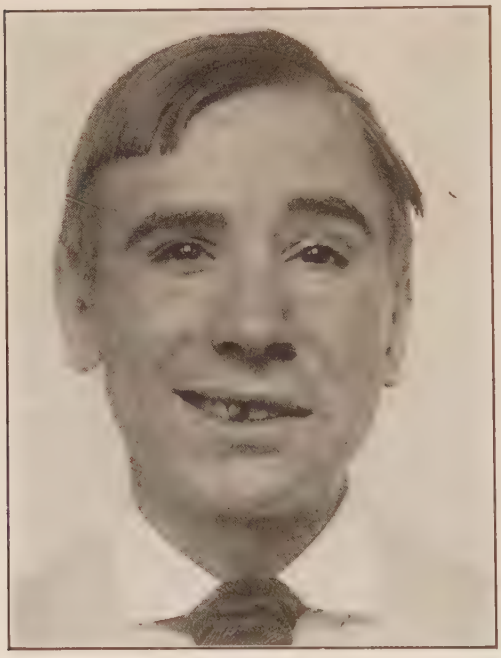


FIG. 170.—SLIGHT FACIAL PARALYSIS FOLLOWING OPERATION FOR MASTOIDITIS. THE NERVE WAS EXPOSED IN THE WOUND, BUT NOT CUT. The patient recovered from the paralysis after a few weeks. (Author's collection.)

Paralysis and Spasm of the Facial Nerve.—Paralysis of the facial nerve may be of central or peripheral origin. The *peripheral causes* are wounds of the nerve in front of the ear, incised or stab wounds or severe contusions, fractures of the base of the skull, injuries during surgical operations upon the parotid or upon the jaws, occasionally in operations for suppurative disease of the middle ear and mastoid; diseases of the petrous portion of the temporal bone, syphilis, and tuberculosis, catarrhal or suppurative inflammation of the middle ear. Exposure to cold and rheumatism are believed also to produce facial paralysis. The *central causes* are injuries, diseases, and tumors of the brain.

SYMPTOMS.—The symptoms of facial paralysis consist of paralysis of some or all of the muscles of the face, according as a part or the whole of the nerve is involved. The normal lines—furrows of the face—are obliterated; the sur-

face of the skin, even in old people, becomes smooth and devoid of wrinkles. The upper eyelid cannot be brought down to close the eye. The conjunctiva is congested. The tears flow out upon the cheek. The nostril upon that side cannot be dilated. The corner of the mouth droops. Saliva may drool from the mouth on that side. The mouth is drawn toward the sound side. The acts of whistling and pursing up the lips cannot be performed. The labial consonants are pronounced with difficulty, or imperfectly. If disease of the middle ear exists, there may be partial deafness. There may be disturbances of the sense of taste. The movements of the tongue are normal. Paralysis of the facial nerve is sometimes one of the symptoms of the so-called head tetanus.

Spasms of the Muscles of the Face.—Spasms of the muscles of the face sometimes occur as the result of direct or reflex irritation of the facial nerve. Such spasms occur frequently in neuralgias of the fifth nerve as the result of reflex irritation. The spasms consist of clonic contractions of the muscles of the face—notably of the orbicularis palpebrarum—and of the muscles of the cheek and mouth. In case the spasm is due to irritation of one of the peripheral branches of the fifth nerve, pressure upon the nerve at the point of exit from its foramen, stops the spasm. In a few instances the spasm may be caused by direct irritation of the facial nerve itself—a neuritis.

INJURIES AND DISEASES OF THE NOSE

Congenital Defects.—Some of the congenital defects of the nose have already been mentioned in speaking of the congenital fissures of the face. Absence of the nose is an exceedingly rare congenital deformity. Occasionally a child is born with the nostrils abnormally small, but this deformity is more frequently acquired as the result of tubercular or syphilitic ulceration. As the result of improper and irregular development of the septum of the nose, the bridge of the nose may take an oblique direction or be crooked. A moderate degree of this deformity is by no means uncommon, but is often so slight that the shape of the nose is not altered, and the deformity of the septum is only appreciated by looking into the nose with a speculum. The entire bony framework of the nose also may have an oblique position, and an ugly deformity may thus result.

Fracture of the Bones of the Nose.—Fracture of the bones of the nose occurs most often as the result of direct violence by blows and falls. The fracture is usually compound into the cavity of the nose, and is attended by hemorrhage from the nose of greater or less severity. The fragments of bone are usually displaced backward, causing a depression of the nose; or backward, and to one side. The signs of fracture—deformity, abnormal mobility, and sometimes crepitation—can be discovered by inspection and palpation. The deformity is usually well enough marked to be easily recognized. The cartilaginous septum of the nose may also be fractured, and produce a bending of the nose to one side.

The Diseases of the Nose.—The borders of the nostrils may be the seat of eczema; of syphilitic, tubercular, cancerous, or diphtheritic ulceration; as well as of the pustules of glanders. I have already spoken of the peculiar hypertrophy of the nose which occurs as an extreme degree of acne rosacea. The noses of those who habitually drink much alcohol are often swollen and red, and dilated blood-vessels may be seen in the skin. Diabetics often have red noses.

Lupus of the Nose has already been described.

Syphilis.—Syphilis in its three stages may affect the nose. Chancre of the nose is, however, extremely rare. Secondary papules, or, in bad cases, ulcerations with loss of substance, involving the alæ, or the tip of the nose, are not uncommon; and the tertiary osteitis and periostitis of the nasal bones, the nasal septum, and the hard palate—which usually begin as such, or are secondary to ulcerations of the mucous membrane—are one of the most characteristic lesions of tertiary syphilis. The process may be limited to the nose, or may involve the upper lip and the alveolar process of the upper jaw. The symptoms may come on quite insidiously, like an ordinary catarrh, and the necrosis of bone may not be recognized until too late for treatment to avail. The condition is easily recognizable in its progressive stage by the character of the gummatous ulceration, by seeing the exposed greenish-yellow or black bone through the mouth or nose, and by the horrible stench which accompanies the process—of which, fortunately for himself, the patient is unconscious. After the sequestra have separated, the well known syphilitic nose, with a depression where the bridge should be, and a turned-up point, constitutes a deformity which needs only to be seen to be recognized (syphilitic saddle nose).

Fig. 171.—Syphilitic Necrosis of the Nasal Bones and Septum, Producing the Typical "Saddle-Nose" Deformity. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

Tumors of the Nose.—The same tumors occur upon the nose as elsewhere upon the face.

Rhinoscleroma.—Rhinoscleroma is a disease which is caused by a specific micro-organism somewhat resembling the pneumococcus of Friedländer, but differing from it. They are short, oval rods surrounded by a capsule. The rods are stained by Gram's method while the pneumococcus is not. The bacillus

retains its capsule in the tissues. The disease apparently never originates in the United States. It occurs in Austria and Russia and in Central and South America. The disease begins upon the alæ or septum of the nose, with the formation of small, rounded, very firm, painless nodules, which slowly increase in size, and may in time cause flattening and broadening of the nose, and more or less interference with breathing through the nostrils. The nodules consist of a reticulum of firm fibrous tissue; the spaces are filled with soft tissue, densely infiltrated with small rounded cells and with much larger round cells of a diameter five or six times as great as that of a white blood corpuscle, containing a hyaline substance, and no nucleus. The bacilli are chiefly found in these large cells. As the disease progresses other nodules are formed, upon the lips, in the pharynx, and in the larynx. Upon the skin the nodule is covered by normal skin, or the skin is thinned and shiny. The nodule is situated in the skin, and moves with it. They are to be *differentiated* from other nodules by their hardness, painlessness, and the fact that they show but little tendency to undergo ulceration; in this they differ from tubercular, syphilitic, or cancerous nodules. When the nodules occur in the larynx, they may give rise to dangerous dyspnea.

The Examination of the Cavity of the Nose.—The examination of the cavity of the nose may be conducted from the front or from the rear—*anterior* and *posterior rhinoscopy.*

Anterior Rhinoscopy.—In order to examine the nose from in front one introduces into the nostril one or other of the forms of nasal speculum, and illuminates the cavity by means of reflected light and a head mirror, or, more conveniently, with an electric headlight. The speculum should be inserted well into the nose, and the tip of the nose may be elevated with the thumb for the purpose. The mucous membrane of the septum of the nose and of the inferior turbinated bone is thus brought into view, and a portion of the middle fossa. It is sometimes possible in normal cases to see the posterior pharyngeal wall in this way; but if the space between the turbinated bone and septum is so large that the posterior wall is visible over a considerable area, the patient is probably suffering from atrophic rhinitis. The muscular movements of the levator of the soft palate, which forms a part of the outer border of the posterior opening of the nose, can be identified by asking the patient to pronounce the letter K or I.

Posterior Rhinoscopy.—Posterior rhinoscopy is used to examine the vault of the pharynx, the orifices of the Eustachian tubes, the posterior nares, and the posterior ends of the turbinated bones. The examination is conducted through the mouth. The instruments used are the head mirror, or electric light; a tongue depressor; a small laryngoscopic mirror on the end of a handle, and usually circular in shape; and sometimes a blunt retractor, which is used to pull forward the soft palate. In very nervous or sensitive persons, painting or spraying the pharynx with a little two-per-cent cocain solution, five minutes before the examination is conducted, sometimes renders it less difficult.

The surgeon sits in front of the patient with the mirror upon his forehead, the tongue depressor in his left hand, and the small laryngoscopic mirror in his right. The patient sits facing the surgeon with his head erect, or bent a little forward. Before introducing the laryngoscopic mirror it should be gently warmed in the flame of an alcohol lamp to prevent the condensation of the moisture of the patient's breath upon the surface of the mirror. The patient is directed to open his mouth; the tongue depressor is introduced well onto the dorsum of the tongue, and the tongue is gently, but firmly, depressed. The small mirror is then introduced, without touching the throat, well behind the soft palate, toward the back of the pharynx. Meantime the patient is directed to breathe naturally. It requires some practice to get a satisfactory view. The posterior border of the septum forms a good landmark from which to judge of the relative position of the structures seen. In some cases a small curved retractor is passed behind the soft palate to draw the structure forward, and increase the space between it and the posterior pharyngeal wall. The patient himself holds the tongue depressor, or a self-retaining tongue depressor must be used. By slight movements of the laryngoscopic mirror the different portions of the vault of the pharynx, the orifices of the Eustachian tubes, and the posterior nares, nasal septum, and posterior extremities of the turbinated bones are brought into view.

Much information in regard to the condition of the upper pharynx, etc., can be gained by digital exploration with the forefinger, introduced through the mouth and passed gently up behind the soft palate. The presence of adenoids, tumors, foreign bodies, exposed bone, etc., may thus be felt. In order to make the examination the surgeon stands at one side of or behind the patient, and holds his head quiet with his left arm and hand, while the right forefinger is introduced into the mouth. In order to avoid the risk of being bitten, it is desirable to place a gag between the patient's back teeth, and have it held by an assistant. Through the anterior nares it is sometimes possible to introduce a probe into the frontal sinus, the antrum of Highmore, and rarely into the ethmoid cells. The manipulations are rather delicate, and harm may be done unless they are performed with gentleness and dexterity. They are not very generally attempted by surgeons. (For a description of the technic, the reader is referred to an article by Prof. W. Kümmel, of Breslau, in vol. i, "A Handbook of Practical Surgery," E. von Bergmann, etc., p. 785 *et seq.*, and to special works on the Nose and Throat.)

Diseases of the Cavity of the Nose.—Nosebleed—Epistaxis.—Nosebleed occurs from injuries and diseases of the nasal mucous membrane and in the course of general infectious diseases; further, in hemophilia, diseases of the heart, obstruction to the portal circulation, cirrhosis of the liver, for example. The local causes, other than injuries, are ulcers of the nose—simple, tubercular, syphilitic, often situated on the septum—tumors and varicosities of the veins of the inferior turbinated bone or septum. The bleeding in most cases takes place from the septum or the inferior turbinated bone near the front of

the nose; the blood escapes through the anterior nares or flows backward into the pharynx. In case it is hard to see the source of bleeding, the nose may be cleaned by snuffing up salt and water, and may then be sprayed or painted with two to five-per-cent cocain solution or with 1–1,000 adrenalin solution. If a patient is unconscious the blood may run down the pharynx into the stomach, and be followed by hematemesis, or down the windpipe, causing asphyxia or, later, septic pneumonia.

Acute Inflammation of the Nasal Membrane—Acute Coryza.—Acute coryza occurs as the result of exposure to cold and wet, and from the inhalation of dust and irritating vapors and gases. It is attended by an increase in the number of bacteria in the nose. The symptoms are interference with nasal respiration—from swelling of the mucous membrane, loss or diminution in the sense of smell and taste, sometimes frontal headache. The discharge from the nose is increased; at first, watery and irritating to the nostrils, later, muco-purulent and thick; in severe cases it may be brownish red and abundant, or blood-stained. The ear and the accessory cavities of the nose may be involved. (Symptoms discussed under Ear, Frontal Sinus, Antrum, etc.)

Chronic Nasal Catarrh.—Chronic nasal catarrh is usually described as existing in two forms, *hypertrophic* and *atrophic rhinitis.*

Hypertrophic Rhinitis.—Hypertrophic rhinitis is attended by chronic swelling and thickening of the mucous membrane, covering especially the inferior turbinated bone, and is frequently accompanied by congenital lateral deviation of the cartilaginous and bony septum of the nose. There is an increased discharge of mucus, or muco-pus, from the nose, more or less interference with nasal breathing. Intercurrent attacks of acute coryza are common, especially during the winter months. The discharge from the nose is not offensive. These patients are sometimes subject to attacks of asthma, to severe headaches, to neuralgia of the fifth nerve, to hay fever, to disturbances of digestion, to chronic catarrhal inflammation of the middle ear, with progressive diminution in the sense of hearing and thickening of the tympanic membrane. The swelling of the mucous membrane of the Eustachian tube prevents the proper equalization of air-pressure between the pharynx and the middle ear. The patients so afflicted are often unable to inflate the middle ear at will. Concavity of the tympanic membrane can be observed. The disease is often complicated by atrophic rhinitis.

Atrophic Rhinitis.—Atrophic rhinitis is characterized by atrophy of the mucous membrane covering the turbinated bones, by a purulent discharge from the nose, by the formation of abundant crusts in the nasal fossæ, by putrefactive changes in the discharge and in these crusts, and a stinking breath (*ozena*). Anterior rhinoscopy permits one to see the crusts, the diminution in size of the turbinated bone, and the increase in the space between this bone and the septum, so that the posterior pharyngeal wall becomes visible over a considerable area. Both atrophic and hypertrophic rhinitis may

be complicated by purulent or catarrhal inflammation of the accessory air cavities.

Perforating Ulcer of the Septum of the Nose.—As the result of traumatisms or infections an ulcer may form on the cartilaginous septum of the nose, of a chronic character, ending in perforation of the septum. The symptoms are nosebleed and a purulent discharge from the nose. The rounded ulcer is visible upon inspection through the anterior nares. The perforation usually heals, leaving a circular defect in the septum.

Gonorrhea of the Nose.—Gonorrhea of the nose is exceedingly rare. The symptoms are an acute catarrh of the nose. The identification of the gonococcus is necessary for a diagnosis.

Diphtheria of the Nasal Mucous Membrane.—Diphtheria of the nasal mucous membrane occurs usually in the back part of the nose, as an extension of diphtheria of the pharynx. Infection of a fissure or abrasion inside the nostrils, on the mucous membrane of the septum, is, nevertheless, possible. Some years ago I suffered from a small ulcer in this situation, which became covered with a diphtheritic membrane, and would not heal. It was followed in a few days by typical pharyngeal diphtheria; paralysis of some of the muscles of the throat followed.

Abscess of the Submucous Tissues of the Nasal Fossæ.—Abscess of the submucous tissues of the nasal fossæ is rather rare, but may occur as the result of traumatisms and infections in the neighborhood of the nose. The symptoms and signs are those of an acute inflammation of the nasal mucous membrane, to which are added pain and sepsis. They are to be recognized usually by direct examination.

Tuberculosis of the Nasal Mucous Membrane.—Tuberculosis of the nasal mucous membrane may be secondary to lupus of the nose and face, or may complicate tuberculosis of the lungs; less often primary tuberculosis of the nasal mucous membrane occurs. The disease is characterized by the formation of tubercular ulcers upon the septum, the floor of the nasal fossa, and the mucous-membrane covering of the inferior turbinated bone. The ulcers have swollen borders irregularly undermined. The base of the ulcer is covered in part by tuberculous granulations, and in part by necrotic material. They are painful and sensitive, and bleed readily. Secondary foci of tuberculosis in the form of small nodules of a pale-red or yellowish-white color may be seen in the vicinity (submiliary tubercles). Sometimes considerable tumors of tuberculous granulation tissue are formed. They may be as large as a pea or larger. They tend to ulcerate upon the surface, but contain few tubercle bacilli, and are therefore not easy to diagnosticate, even under the microscope.

Syphilis of the Nasal Fossæ.—Chancre and secondary syphilitic papules and pustules may occur in the interior of the nose, but by far the most common lesions are the tertiary, circumscribed, and diffuse gummatous inflammations of the mucous membrane, periosteum, and bone, already described. The course

of the necrotic process is exceedingly chronic. The diagnosis, as a rule, quite plain.

Foreign Bodies in the Nose.—The diagnosis of foreign bodies in the nose is usually easy. The bodies are introduced chiefly by children and lunatics. Usually the surgeon is called for the express purpose of extracting a body, known or believed to have been inserted into the nose. Occasionally pieces of gauze or other material inserted into the nose to stop nosebleed may be forgotten and require extraction. If the foreign body is in the front of the nose it may be discoverable even without the use of a speculum. If it is in the posterior nares a finger introduced through the mouth will discover it. If the foreign body has long remained in the nose, it will set up inflammation or ulceration, by pressure, and produce a purulent or bloody discharge. Under such circumstances the foreign body will be coated with dried mucus, and may not be readily recognized on inspection of the nasal cavity. Sometimes the presence of a foreign body will give rise to the formation of a concretion, by deposition of mucus, and of earthy salts. The symptoms produced will be the same as though caused by ordinary foreign bodies, which have long remained in the nose.

Insects and the larvæ of insects occasionally gain access to the nose, and, if they remain, give rise to irritation and inflammation, sometimes of a serious or dangerous character. Many varieties of living worms, insects, and maggots have been extracted from the nose. I once extracted a living many-legged creature an inch and a half in length from the nose of a man who had been eating raw oysters; he had taken the animal into his mouth with the oyster, and it had crawled up behind his soft palate and into his nose, and set up an irritation.

Tumors of the Nasal Fossæ.—The commonest tumors of the nasal fossæ are the so-called *nasal polypi*. They are localized hypertrophies of the nasal mucous membrane which form rounded, sessile, or pedunculated excrescences upon the mucous membrane of a dirty-pink, bluish-gray, or white color, and of soft consistence. They often undergo cystic degeneration, and may form cystic tumors of some little size, filled with mucus. Such a tumor may be formed in one of the accessory cavities of the nose, the frontal sinus, or the antrum, and grow until it fills the cavity. The symptoms produced by nasal polypi are those of chronic catarrhal inflammation of the nose, together with obstruction of the nasal fossæ. The diagnosis of nasal polypi is easy; sometimes a polypus may be present in the nostril, or they may be seen by inspecting the interior of the nose. They are often multiple, and may be present at the posterior nares, so that palpation of this region should not be omitted in making the diagnosis.

Lipoma of the interior of the nose is one of the rarest of tumors. Fibroma and chondroma are seldom observed; they are both to be distinguished from polypi by their greater hardness. Osteoma is also a rare tumor in the nose, as is also carcinoma. Carcinoma sometimes follows atrophic rhinitis or syphi-

litic ulceration. Sarcoma originates from the cartilaginous and bony framework of the nose.

Signs and Symptoms.—The signs and symptoms produced by these tumors, innocent and benign, vary greatly in different cases according to their size and origin and mode of growth. The first symptom noticed by the patient is usually difficulty in breathing through one side of the nose. If the tumor attains a large size it invades the accessory cavities of the nose, the antrum, the frontal sinus, the ethmoidal cells, grows backward into the pharynx, sometimes into the orbit. If malignant it grows into the mouth and invades the cranial cavity, the bones of the face are deformed, forced apart, and destroyed, and horrible deformities are produced.

Tumors originating on the septum produce, as a constant symptom, interference with breathing; those which originate in the front part of the nose tend to produce a bulging at the root of the nose and to involve the orbit; those starting in the root of the nose tend to invade the base of the skull and the brain. Tumors which arise in the anterior part of the ethmoid bone are quite apt to involve the muscles of the eye and their nerves; further, to produce disturbances of vision by pressure upon the optic nerve. Where a malignant tumor of this region has invaded the interior of the skull it is very apt to cause a purulent fatal meningitis. Further, tumors which grow backward may cause severe neuralgic symptoms by pressure upon the branches of the fifth pair of cranial nerves. Tumors which grow into the antrum of Highmore frequently cause purulent inflammation of the antrum with the corresponding symptoms. Carcinomata are very apt to undergo early ulceration and to bleed freely. Putrid decomposition of the sloughing tumor tissues is accompanied by a foul odor of the breath. The sarcomata, with the exception of the round-celled form, are less apt to ulcerate and to bleed, except when they project into the pharynx. At the time when the patients present themselves for examination the tumor, if malignant, has usually attained so large a size, and has so widely invaded the surrounding soft parts and bones, that it is impossible to say whether it originated in the nose or in the jaw or in the antrum. A discussion of the further signs and symptoms of malignant tumors of this region is continued under Tumors of the Upper Jaw, and of the Antrum of Highmore.

THE JAWS

Fractures.—Fractures of the Upper Jaw.—Fractures of the upper jaw always occur from direct violence. If the violence is moderate one or other of the processes is broken rather than the body of the bone. The direction of the line of fracture is very varied, according to the direction and character of the force. A blow upon the cheek may crush the malar bone into the antrum. By a blow upon the upper lip a fracture of the alveolar border can be produced. The nasal process is frequently broken by blows upon the

nose. Severe degrees of violence may separate the superior maxillary bones one from the other. I have seen a case in which the kick of a horse created a central fragment, with backward displacement; the line of fracture ran vertically upward, outside of either canine tooth. Gunshot fractures may produce any possible degree of destruction of the bone. The diagnosis of fractures of the upper jaw is, in most cases, entirely easy. A large part of the bone is open to direct inspection and palpation. All the signs of fracture are usually present. In cases of doubt ecchymosis in the roof of the mouth would suggest the presence of a fracture. In severe fractures from direct violence and from gunshot wounds, the internal maxillary artery may be torn, with serious bleeding. The infra-orbital nerve may be injured; less often the facial.

Fractures of the Malar Bone and of the Zygomatic Process.—Fractures of the malar bone and of the zygomatic process are quite rare as isolated injuries. They are frequently combined with fractures of the upper jaw. The zygomatic arch is more commonly broken by direct violence than the body of the bone. The deformity is usually a depression or flattening of the cheek, easily recognized by sight and by palpation, although a good deal of swelling is usually present. Mobility and crepitus are less commonly observed. Disturbances of sensation in the nose, cheek, and upper lip, together with exophthalmos, and later ecchymosis into the conjunctiva, indicate that the fracture has extended into the floor of the orbit and has injured the infra-orbital nerve. If the zygomatic process is driven inward, it may press against the coronoid process of the lower jaw, and thus interfere with the movements of that bone.

Fractures of the Lower Jaw.—The lower jaw is broken more often than any other bone of the face. The most frequent cause is a blow upon the chin. Much less often, a blow from the side. Double fractures are by no means rare. The fracture is rarely comminuted except in the case of gunshot fractures. The coronoid process is very rarely broken. The condyloid process more frequently, and its fracture is often associated with fractures of the other bones of the face.

Fracture of the Alveolar Border.—Fracture of the alveolar border is common, as are also fractures through the body of the jaw. Fractures of the body behind the teeth are rare. In the fractures in the horizontal portions of the body, the line of fracture is usually vertical or only slightly oblique. Fractures through the angle or ascending ramus are oblique or transverse. Owing to the proximity of the mucous membrane of the mouth many fractures of the lower jaw are compound; the diagnosis is usually simple; all the signs of fracture are present in many cases. In fractures through the front part of the body, an irregularity in the line of the teeth can usually be seen or felt. In double fractures with a central fragment, the middle part of the jaw is drawn downward by the muscles attached to its posterior surface.

Fractures behind the teeth and of the ascending ramus are not so easy to

discover; deformity may sometimes be detected with the finger introduced into the mouth; crepitation is less often present. A fixed point of pain and tenderness and pain on motion may be the most prominent symptoms. Although sometimes possible, it is difficult to detect these fractures by means of the X-rays. The signs of fracture of the condyloid process are localized pain and tenderness, pain on motion, and diminished mobility, sometimes crepitation. The entire jaw is sometimes slightly displaced toward the injured side, and the condyloid process itself can be felt to be displaced forward and may be partly dislocated into the zygomatic fossa. In fractures of both condyloid processes the entire jaw may be displaced backward. Fractures of the coronoid process alone are caused only by direct violence to that region. Failure of union in fractures of the lower jaw is exceedingly rare.

Dislocation of the Lower Jaw.—The jaw is dislocated forward in by far the largest proportion of cases. Dislocation backward with fracture of the anterior wall of the auditory canal is rare, and is due to extreme degrees of violence by blows upon the chin. A single case is on record where, following a severe blow upon the chin, the condyle of the bone had been driven into the cranial cavity, and finally had produced a fatal abscess of the brain. The forward dislocations are bilateral in more than half the cases. The dislocation is usually caused by muscular action during the act of yawning or vomiting, rarely by a blow upon the jaw with the mouth open or in the effort to force some very large object into the mouth.

The *signs and symptoms of bilateral dislocation* are as follows: The mouth is held open, the jaw projects forward and cannot be moved. The condyle of the jaw can be felt anterior to its normal place, and a corresponding depression can be felt at the site of the glenoid cavity. The cheeks are flattened, the masseter muscles are usually tense. The saliva drools from the mouth. Speaking and swallowing are difficult. In *unilateral dislocations* the articular process will be absent from the glenoid cavity upon only one side. The chin is displaced a little toward the uninjured side. The jaw may still retain some mobility. Backward dislocation of the jaw is usually accompanied by fracture of the anterior wall of the auditory canal. The entire jaw is displaced backward. The jaw is immovable. There is hemorrhage from the external ear. The condyle of the jaw is absent from its normal position; the mouth is held partly opened. The dislocation may be unilateral or bilateral.

The Teeth.—Caries of the teeth gives rise to the formation of cavities and gradual destruction of the teeth, recognizable upon inspection and exploration of the affected teeth. The carious areas may be covered by tartar, which requires removal before the black or yellow discolorations and pits in the teeth can be seen and felt. The retention and decomposition of particles of food in the cavities cause the breath to be offensive. The subjective symptoms vary; there may be none. Ordinarily exposure of the dentine causes the tooth to become sensitive to heat, cold, and acids. Sometimes tenderness on pressure exists, and even pretty severe toothache. The tenderness may sub-

side from atrophy of the dentine, and no further pain be felt until the pulp is exposed; extreme sensitiveness and pain then occur. Exquisitely sensitive granulations sprout from the exposed pulp. Granulation tissue of an inflammatory origin may also form between the tooth and its socket in the jaw (granulomata); the tooth will then be painful, sensitive, and sometimes a little loose.

Infection with pus microbes leads to the formation of an abscess, either at the root of the tooth between the tooth and the jaw, or between the tooth and the gum, or to a purulent pulpitis, or a purulent periostitis of the alveolar process, or both. In the first instance the *symptoms* are a severe throbbing toothache, swelling of the gum, sometimes edema of the face and fever. The pain is of a throbbing, boring character; is worse at night. The tooth becomes exquisitely sensitive; sometimes it is raised a little from its bed, so that it projects slightly beyond the normal line of the teeth. If the inflammation is confined to the periosteum of the alveolar process, the pain will be less severe, and an abscess (parulis) or so-called "gum-boil" will form in the neighborhood of the tooth, and present as a fluctuating, tender swelling of the gum, and finally burst, with relief of the symptoms. A purulent sinus, or tooth fistula, often remains and discharges a little pus continuously or intermittently. The chief interest to the surgeon in these conditions lies in the fact that in neglected or improperly treated cases severe septic processes may occur, involving purulent periostitis and osteitis of the jaw, sometimes followed by extensive necrosis, as well as septicemia, which may be dangerous or fatal. An abscess at the root of a canine tooth may break into the antrum and cause suppuration in that cavity. An abscess at the root of a molar tooth, with periostitis of the jaw, is not infrequently accompanied by some degree of immobility of the jaw—inflammatory lockjaw, in other words. Tumors connected with the development of the teeth have been described in the chapter on Tumors.

Inflammation of the Gums (*Gingivitis*).—The causes of gingivitis are want of cleanliness and the accumulation of tartar at the necks of the teeth between the teeth and the gums. The gums are somewhat retracted, a little swollen and tender; there may be a moderate purulent discharge from the border of the gums; the breath may be fetid. The presence of accumulated tartar is evident on inspection.

Chronic Pyorrhea Alveolaris (*Riggs's Disease*).—Chronic suppurative inflammation of the gum, at its junction with the neck of the tooth, gradually extending between the tooth and the alveolar process, with atrophy of the bone, is a disease rare in young adults; it occurs more often during middle life. Its origin is obscure. Depressed states of health favor its occurrence—tabes, malarial poisoning, gout, etc. It may affect but one tooth, or several, or nearly all the teeth in succession. The symptoms are characteristic. The gum is swollen, retracted from the neck of the tooth. There is usually, not always, a purulent discharge from between the tooth and the gum. There

is often some pain, notably upon the exposure to cold, and after taking hot or cold or acid liquids into the mouth. The progress of the disease is continuous but slow; gradually the gum retracts more and more from the tooth, atrophy of the alveolar socket follows, the tooth becomes finally loosened in its bed, and is lost, often without any signs of disease of the tooth itself.

Gingivitis from Other Causes.—Other causes of gingivitis, sometimes of an ulcerative character, are poisoning by lead and mercury, and scurvy.

Lead Poisoning.—Poisoning by lead occurs, notably among house painters, from neglect of proper precautions. The gums are swollen, tender, and red; there is a purulent discharge. Along the edge of the gums there is a distinct blue or gray line of discoloration; the breath is often fetid. Lead palsies, notably "drop wrist" (*musculo-spiral paralysis*), anemia, colics, and other signs, are usually present.

Mercurial Poisoning.—In mild cases the gums are moderately swollen, tender and spongy, and bleed easily; slight tenderness is felt upon sharply closing the teeth; there is slight salivation; often diarrhea. In severe cases the inflammation may proceed to ulceration. There is profuse salivation, the entire mucous membrane of the mouth is swollen, the breath is fetid, anemia and diarrhea or dysentery are usually present. There is retraction of the gums from the teeth during recovery, and this retraction, if the poisoning was severe or long continued, is permanent.

Fig. 172.—Periostitis of the Lower Jaw with Abscess of the Cheek. Infection from a carious tooth. (New York Hospital, Out-Patient Department.)

Scurvy.—The gums are swollen and spongy; there is a purulent discharge; bleeding from the gums is the rule. The teeth may be lost. There are subcutaneous hemorrhages elsewhere on the body, notably in the legs, sometimes ulcerations. There is a history of improper feeding. Scurvy is not uncommon among children as the result of an exclusive diet of milk sterilized by heat.

Acute Suppurative Periostitis and Osteitis of the Jaws.—Acute suppurative periostitis follows infection through a diseased tooth more often than any other cause. Injuries, such as wounds and fractures, may be followed by a similar condition. The symptoms are localized pain, tenderness, and swelling; more or less marked sepsis; lockjaw is present or absent, according to location. Usually an abscess follows in the soft parts, which may point externally upon the face or in the mouth; fetor *ex ore* is common. A severe form of purulent periostitis and osteitis occurs in the jaws of children during acute infectious diseases, especially the exanthemata, notably when the mouth

is not kept clean. The general symptoms are severe, and the local lesion often extensive. The diagnosis is readily made from the local signs and symptoms. A purulent discharge from the tooth sockets is often present.

Syphilitic Gummatous Osteitis and Periostitis of the Jaws.—Syphilitic gummatous osteitis and periostitis of the jaws are less common than similar affections of the nasal septum and hard palate; the affection is exceedingly chronic and tedious. I recently saw a young man with syphilitic necrosis of the central portion of the superior maxilla. The upper lip was perforated and nearly destroyed, the nasal septum was gone. The area of necrosis in the jaw involved the entire thickness of the alveolar border, and included the hard palate. The sequestrum of the jaw measured two inches and a half from side to side. The odor was overpowering. The patient felt very well and had no pain.

Tuberculosis of the Jaws.—Tuberculosis of the jaws is relatively infrequent. Infection may be primary in the bone, or secondary to tuberculous ulceration in the mouth. Usually the area of bone affected is not large. Here, as elsewhere, the disease is characterized by its chronic course; perforation of the bone and periosteum; the formation of a cold abscess. Incision reveals a focus of tuberculous caries, usually of moderate size; the bone is softened and friable. A tuberculous sinus usually remains unless the focus is removed by operation. The commonest situation is the superior maxillary bone at the lower border of the orbit. A sinus, surrounded by a puckered cicatrix, remains after spontaneous evacuation or incomplete operation.

Actinomycosis of the Jaws.—Primary actinomycosis of the jaw, although very common in cattle, appears to be exceptional in man. The invasion of the bone is usually secondary to disease of the soft parts. Undoubted cases of infection of the jaw through a carious tooth have, however, been reported, the fungi having been demonstrated in the tooth cavity. In many cases the disease begins in the neighborhood of a tooth, often carious, either in the gum or in the periosteum of the alveolar border, and forms a slowly increasing swelling ending in an abscess. The course is notably slower than in ordinary acute abscess. In other cases a slowly progressive infiltration of the cheek is observed. The swelling is at first rather soft, later becomes extremely hard, and finally breaks down, forming an abscess. The progress is usually quite slow and chronic. The micro-organisms can be identified in the discharge, in scrapings, in the tissues, and by cultures. Mixed infections are common after the lesion is open. In a case of my own (a young girl) a diagnosis of a chronic periostitis of the lower jaw with abscess of the lower part of the cheek was made. Upon opening the abscess the presence of numerous yellowish-white granules in the pus directed attention to the correct diagnosis. Infection had occurred through the gum. A small superficial area, only, of bone was involved. (See Actinomycosis.)

Phosphorous Necrosis.—Phosphorous necrosis, usually of the lower, rarely of the upper, jaw, was formerly a common condition among makers of phos-

phorus matches. At present it is exceedingly rare in America. The phosphorus fumes entering into the cavities of carious teeth cause a productive periostitis with the formation of osteophytes and thickening of the bone. Later, or in some cases primarily, purulent inflammation of the bone and periosteum, with sometimes total necrosis of the jaw, follow. The history, the pain, swelling, and discharge of pus from the emptied tooth sockets render the diagnosis easy.

Diseases of the Antrum of Highmore.—Hydrops of the Antrum.—Hydrops of the antrum occurs from stoppage of its outlet into the nose and from cystic degeneration of polypoid growths of the antrum, or from cysts developed in connection with the teeth in the wall of the antrum, which subsequently enlarge and occupy that cavity. The symptoms are chiefly those produced by pressure. The anterior wall of the antrum is thinned and protrudes as a bony or parchmentlike swelling, palpable within the mouth above the reflection of the mucous membrane from the alveolar process to the upper lip. A similar condition may exist in the hard palate. The presence of a carious canine tooth points to an infectious origin. In the pure cases of hydrops or mucous cyst an aspirating needle introduced through the anterior wall of the antrum withdraws clear, thin fluid or mucus.

Empyema of the Antrum.—Empyema of the antrum occurs from infection through a carious tooth as the result of infected fractures and stab wounds involving the antrum, from the presence of foreign bodies in the antrum (bullets, portions of a knife blade, etc.), and lastly as a complication of malignant tumors of the upper jaw, the nasal fossæ, and the orbit. The symptoms are various, according to conditions; when due to infection from a tooth, the withdrawal of the tooth will be followed by a continuous or intermittent discharge of pus in considerable quantity from the tooth cavity. If the outlet into the nose remains open, pus will be discharged from the nose —notably when the patient lies upon the sound side. If the outlet becomes closed, accumulation of pus will lead to distention of the antrum. Symptoms of septic absorption, together with pain and tenderness over the antrum and swelling of the face, will follow. If the anterior wall is perforated, an abscess or a septic cellulitis of the face with grave symptoms of sepsis, or pyemia and death, may result.

The diagnostic signs and symptoms, other than the above, are a unilateral discharge of pus from the nose, sometimes having a fetid odor, which the patient is able to detect, thus differing from ozena and syphilis. In some cases the surgeon may be able to see pus coming from the middle meatus of the nose by anterior rhinoscopy with the head tipped back. In others, transillumination of the sinus by an electric light held in the mouth is useful. If the antrum is filled with pus it may appear to be more opaque than the antrum of the sound side, not a very definite sign in many cases. The examination must be conducted in an entirely dark room. The patient takes a small electric light into his mouth and closes his lips. Upon illumination of the lamp, that

side of the face and pupil of the eye will, in some instances if the antrum is filled with pus, appear dark or less brightly illuminated than the sound side.

The Tumors of the Antrum of Highmore.—The most common tumor is the soft polypus, such as occurs in the nose. It will give rise to no symptoms unless it happens to occlude the passage into the nose or undergo cystic degeneration, as already described. Other tumors, such as carcinoma, sarcoma, enchondroma, and myxoma occasionally occur in the antrum. They give rise to symptoms only when they have reached such a size that they fill and distend the cavity.

Tumors of the Jaws.—Tumors may affect the alveolar processes of the jaws or the bodies of the jaws. A general term, long in use to indicate tumors arising from or upon the gums, is *epulis*. Among them are small *fibromata* which may develop upon the gums, usually of children. They are generally hard, insensitive tumors of a red or bluish-red color, of slow growth. Combination forms, with sarcoma, are exceedingly common.

Granuloma.—After the extraction of teeth in children, and from the cavities in carious teeth which expose the pulp, and after fractures of the teeth with exposure of the pulp, there sometimes sprout little masses of granulation tissue which, after a time, may become fairly firm and insensitive. Similar tumors may grow from the margin of a sinus leading to the root of a decayed tooth. They are usually bright red or pink in color, and of an uneven, granular surface. Their appearance and origin establishes the diagnosis. The *fibro-sarcomata* frequently occur upon the alveolar border of the jaws. They may originate from the gum, or from the periosteum, or from the medulla of the bone. Those which originate from the periosteum and the gum are firm and elastic, rounded or flattened, sessile or pedunculated tumors, of moderate size, containing giant cells, and often of slight malignancy. When they originate in the medulla of the bone they cause enlargement of the bone and its final perforation by absorption. They are usually tumors of rather slow growth. Such tumors may originate in the wall of the antrum, and after filling that cavity may cause distention and perforation with pressure symptoms and deformity.

Odontoma.—The tumors arising from tooth germs have already been fully described under Tumors.

Enchondroma and *osteoma*, when they grow from the alveolar border, are to be recognized by their slow growth, by their hardness and absence of the signs of malignancy. They may produce severe pain from pressure upon nerve trunks. The various forms of *sarcoma* may arise from the alveolar processes of the jaw; the most common among them are the giant-celled sarcomata. The more malignant forms may also occur, but more commonly originate in the body of the jaw.

Carcinoma originates from the pavement epithelium of the gums. The first symptoms noticed by the patient may be lossening of one or more teeth.

The gum in the neighborhood will be thickened and swollen, and will soon ulcerate; a bloody, purulent discharge is then present. Putrefactive changes occur, and the breath acquires a fetid odor. The loosened teeth fall out. The ulcerative process extends and is sometimes accompanied by papillary outgrowths somewhat resembling a cockscomb. The bone is soon invaded and destroyed, and the subsequent progress of the disease is from bad to worse, as is the case with carcinoma elsewhere. The cancers originating from flat epithelium are typical *epithelioma ta*. The disease occurs in elderly persons, and its rapid progress soon makes the diagnosis clear. In case of doubt a bit of tissue may be removed for microscopical examination.

Tumors of the Bodies of the Jaws.—The tumors of the bodies of the jaws belong, for the most part, to the connective-tissue group. The benign forms are the fibroma, enchondroma, and osteoma. The *fibromata* cause, as already stated, enlargement and final perforation of the bone. In some cases the periosteum remains intact and continues to produce a thin layer of new bone around the tumor until the bone may be dilated to a large size. Although these tumors are benign and of slow growth, they may reach a very large size and produce extraordinary and hideous deformities. They are generally hard or firm tumors, show no tendency to infiltrate the surrounding parts, nor are they apt to undergo ulceration unless they are exposed to irritation in the interior of the mouth, pharynx, or nose; such ulceration as occurs is usually superficial. Their symptoms are caused chiefly by pressure, deformity, and mechanical interference with function. Combinations with osteoma, enchondroma, myxoma, and sarcoma are common. Sarcomatous degeneration may also occur in a fibrous tumor; it will then acquire the characters of a malignant growth. The *enchondromata* occur in young persons, usually from the periosteum rather than the medulla. As a pure form of tumor they are extremely rare, but are fairly common in combination with fibroma, myxoma, and osteoma. Like the fibromata, they may grow to a large size, invade the various cavities of the face, cause absorption and dilatation of bone, and remarkable deformities. The history

Fig. 173.—Enormous Mixed Tumor Growing from the Body of the Lower Jaw of a Generally Benign Character. (Collection of Dr. Charles McBurney.)

their growth resembles that of fibroma. They are, of course, hard tumors. The general health is not affected. *Osteoma* may occur as a circumscribed or more diffuse growth from any portion of the jaws. They frequently result from ossification of an enchondroma. They are hard tumors of slow growth and benign characteristics, though they may attain great size. They are sometimes multiple.

Leontiasis Ossium.—Diffuse production of new bone in connection with the jaws, the other bones of the face, and the cranium, occurs as a rare disease to which the name *leontiasis* has been given. The entire skull may be so increased in thickness that the dried skull may weigh four or five times as much as it should. In the few cases reported the disease has developed in early life, and has extended over a period of many years. One of the bones of the face is usually affected, and as time goes on one bone after another becomes enlarged, thickened, with a development of prominent bony masses here and there. A slowly progressive interference with the function of organ after organ, and cavity after cavity, takes place by pressure, until the patient's death.

Sarcomata.—Sarcoma is the most frequent form of tumor affecting the jaws. It may occur alone or in combination with the benign forms—fibroma, chondroma, osteoma—often as a degenerative change in the latter. All varieties of sarcoma develop in the jaws—round, spindle, giant, and mixed-celled forms. The round-celled sarcoma is the most malignant type, and may destroy life very rapidly. The sarcomata may grow from the periosteum, the substance of the bone, or may be primary in the soft parts, and involve the bone secondarily. The sarcomata of the jaws show a common tendency to grow rapidly, to infiltrate and destroy the bones and soft parts, to produce rapidly progressive deformity, to invade the cavities of the face and the skull, undergo degenerative changes, to ulcerate and bleed when they reach the surface of the mucous membrane, and to destroy life. Death occurs from repeated hemorrhages, from sepsis, pneumonia, from invasion of the interior of the skull, and from exhaustion.

Fig. 174.—Giant-Celled Sarcoma of the Upper Jaw. (Kindness of Dr. W. S. Halsted, of Baltimore.)

Carcinoma of the Jaws.— Carcinoma of the jaws occurs, for the most part, secondary to carcinoma of the glandular organs, or to epithelioma of the skin, or of the mucous membrane of the mouth, the tongue, the nose, or its accessory cavities. The tumors rapidly infiltrate and destroy the bone; soon grow beyond the reach of operative interference, and destroy life in one of the ways already indicated as peculiar to malignant tumors. The carcinomata are apt to undergo early ulceration with putrefactive changes, to bleed, and to produce intoxication by the absorption of putrid and septic products.

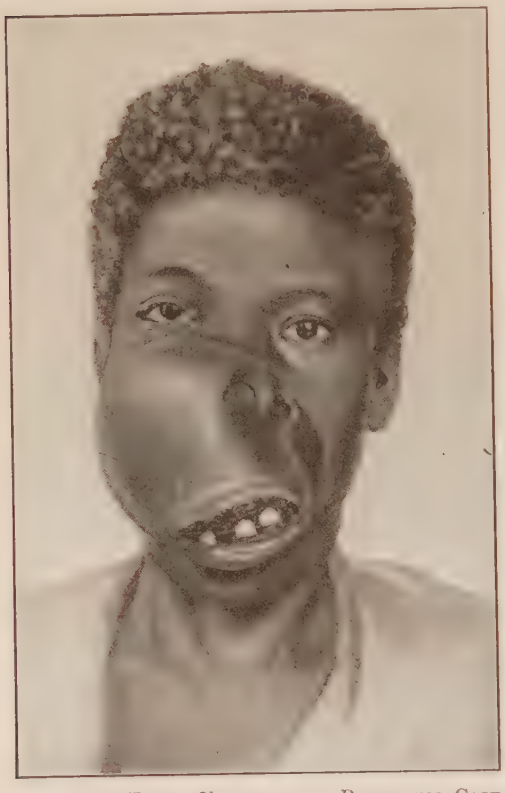


Fig. 175.—Front View of the Preceding Case of Giant-Celled Sarcoma of the Upper Jaw. The patient had observed the presence of the tumor for several years. She was a negress aged about fifty years. Operative removal of both superior maxillæ was followed by death from shock in six hours.

Diagnosis of Malignant Tumors of the Jaws.—In regard to the diagnosis of the malignant tumors of the jaws, it may be said that sarcomata occur for the most part in young people, or before middle age; carcinoma, on the other hand, is developed in advanced life. Sarcoma is not infrequently associated with traumatism and, in a good many instances, with extensive caries of the teeth and inflammatory conditions of the gums. The sarcomata of the alveolar processes are more frequent than those of the body of the jaw.

Clinically, the *sarcomata* may be hard or soft; the majority of those developing from the periosteum are fairly hard tumors. Those growing from the medulla are apt to be softer and more malignant. Cystic degeneration and hemorrhages into the substance of the tumor are more common in the softer forms. The cystic cavities contain bloody, or brown, serous fluid, or gelatinous and crumbly masses of a dirty-brown color. The central sarcomata, at first, dilate the bone, then perforate it; rapidly invade the cavities of the face, notably the mouth, the antrum, and the nasal cavity; sometimes penetrate the skin, ulcerate, and form fungating bleeding masses. In the upper jaw the early symptoms may be those of suppuration of the antrum—a frequent complication of malignant tumors in this region. The central growths cannot always be recognized at a single examination, during the early stage of their development,

before they have broken through the bony capsule. The perforation of the jaw, and even the formation of a distinct enlargement, is usually preceded by continuous dull pain. On the lower jaw they form rounded tumors of a variable size; small at first, later sometimes as large as a child's head. In the upper jaw, in addition to the deformity, there is early interference with nasal breathing, parchmentlike thinning of the bone in accessible situations, with crackling on palpation. Later, softening, with pitting on pressure. Secondary involvement of lymph nodes is the exception rather than the rule.

Further, it may be said that the prognosis of the harder forms, growing from the periosteum, is much better than is the case with those developing from the cancellous tissue of the bone itself.. The *carcinomata* of the jaw occur, as stated, for the most part, as secondary tumors following cancer of the lip, the tongue, the floor of the mouth, the gums, the parotid and submaxillary glands, etc. Occasionally they have their origin in displaced epithelial germs in the bone itself. They are tumors of advanced life, and occur much more frequently in the upper than in the lower jaw. As already stated, it is usually impossible to say, in the given case, whether the tumor originated in the mucous membrane of the nose or antrum, or in the bone itself.

The *symptoms* are pain, referred to the teeth, sometimes radiating into different parts of the head or face; or a dull pain, referred broadly to one side of the face. In the upper jaw interference with nasal breathing is an early symptom. Inspection through the nose, or palpation in the throat, may discover one or other side of the nose more or less completely filled with soft, bleeding masses of tumor tissue. The teeth become loosened and leave carcinomatous ulcerations behind. There follow swelling and infiltration of the soft tissues of the face. As the tumor approaches the surface the skin becomes infiltrated, immovable, hardened, and reddened. Perforation of the skin and ulceration occurs relatively late in the disease, if at all. Invasion of the orbit causes exophthalmos, disturbances of vision and blindness. In the lower jaw involvement of the submaxillary lymph nodes is early noticeable. The destructive process in the bone is so rapid, ulceration and pyogenic infection occur so early, together with toothache, loss of teeth, and suppuration, that the tumor may be mistaken for periostitis, or osteitis of the jaw with abscess. In fact, necrosis of a considerable mass of bone is not very rare as the result of rapid degenera-

FIG. 176.—TUBERCULOUS OSTEOMYELITIS OF THE LOWER JAW IN A BOY. The child also suffered from a tuberculous elbow, tuberculous ribs and empyema. (Case of Dr. Charles N. Dowd, St. Mary's Hospital.)

tive changes in the tumor. The prognosis of carcinoma of the jaw is the worst possible.

Diseases of the Temporo-maxillary Articulation.—Acute Synovitis.—Acute synovitis of the temporo-maxillary joint may occur as the result of acute rheumatism; in the course of acute, infectious diseases; as acute gonorrheal synovitis. The diagnosis is made by the recognition of pain, swelling, and diminished mobility, or pain on motion, in the joint, together with the concomitant rheumatic affections of other joints, the presence of gonorrhea, measles, scarlatina, etc.

Inflammatory Closure of the Jaws.—There is complete, or incomplete, immobility of the temporo-maxillary joint when acute inflammatory processes exist in the neighborhood—mumps, abscesses in the region of the lower molars, acute suppurative tonsillitis, pretonsillar abscess, etc.

Tuberculosis.—Tuberculosis of the joint is rare, and is usually secondary to tuberculosis of the temporal bone. The signs are those of tuberculosis of joints, a chronic course, pain on motion, the formation of sinuses, a sequestrum, etc. Ankylosis is an uncommon result.

Arthritis deformans.—Arthritis deformans of the joint is rare: it is attended by fibrous degeneration of the cartilage; by the formation of osteophytes, absorption of bone, relaxation of the ligaments with complete, or partial, habitual dislocation of the joint, or by fibrous or bony ankylosis with inability to open the mouth.

Causes of Locked Jaws.—Inability to open the mouth may proceed from general conditions affecting the muscles and the nerves, such as tetanus. From spasm of the muscles due to irritation of the fifth pair of cranial nerves, especially the third branch, to injuries or diseases of the soft parts or bones in the vicinity of the joint; and, finally, to affections of the joint itself. Some of the causes have already been mentioned; they may be enumerated as follows: Inflammations connected with the back teeth and the jaw, such as abscess, periostitis, the irritation produced by molar teeth about to penetrate the gum, abscesses and phlegmonous inflammations of the salivary glands, abscesses in the throat, in the soft parts of the cheek and the upper part of the neck; as the result of central nervous causes—i. e., hysteria; from cicatricial contraction following injury or disease of the cheeks, parotid, or temporal regions, notably after gangrene of the face (*noma*); following fractures of the jaw, with deformity, or bony ankylosis between the jaw and the zygomatic process. Finally, as a congenital malformation with an abnormal development of the coronoid process, such that mechanical interference with motion exists. This deformity is combined with arrest of development, and abnormal smallness of the lower jaw. The diagnosis depends upon a search for the cause of the immobility.

CHAPTER XVI

INJURIES AND DISEASES OF THE MOUTH AND THROAT

DISEASES OF THE MUCOUS MEMBRANE OF THE MOUTH

Catarrhal Stomatitis.—Under the head of Bacteriology of the Mouth it was pointed out that the mouth was the home, under normal conditions, of a great variety of bacteria, pathogenic and nonpathogenic. Stomatitis occurs as the result of mechanical, thermal, and chemical irritations. Further, in the absence of proper cleanliness, one or other variety of bacteria may cause inflammation of the mucous membrane of the mouth of any grade of severity. A catarrhal inflammation, slight or severe, ulceration, or, under favorable conditions, gangrene.

Catarrhal Inflammation.—Catarrhal inflammation is characterized by redness, tenderness, and swelling of the mucous membrane; by desquamation of the epithelium; by an increased secretion of mucus, containing a greater or less proportion of leucocytes. There may be small erosions and superficial ulcerations.

Ulcerative Stomatitis.—Ulcerative stomatitis occurs in conditions of general depression, in the course of acute infectious disease, as the result of poisoning by mercury and lead (as already described under affections of the gums), in scurvy. All the forms of ulcerative stomatitis occur most often, and are of the greatest intensity, among those who have neglected the due precautions of cleanliness—cleaning the teeth, the use of mouth washes, periodic visits to a dentist, etc. In ulcerative stomatitis the signs and symptoms of the milder form are present, but are more intense. The ulceration is found especially upon the gums, in the vicinity of carious teeth. The necks of the teeth are surrounded by a collar of greenish-yellow material consisting of bacteria, epithelial cells, and pus. The breath is commonly fetid. Ulcers may also be developed upon the cheeks, opposite a sharp carious tooth, in the floor of the mouth, upon the tongue, etc. Salivation is often present, the tongue may be swollen, pain and tenderness are marked. The patients are only able to take bland soft solids and liquids, and that with difficulty. The submaxillary lymph nodes are enlarged and tender, periostitis, abscess, etc., are not uncommon. (For Gangrenous Stomatitis, see Noma.) (See Fig. 160.)

Thrush.—As the result of the development of a fungus (saccharomyces albicans) there develop in the mouths of suckling and teething children small,

grayish-white plaques, surrounded by a narrow inflamed border. The plaques are covered by a thin layer of dead epithelium in which the fungus is growing. A general catarrhal inflammation of the mucous membrane of the mouth is often present. Other micro-organisms are usually concerned in the process.

Erysipelas of the Mucous Membrane of the Mouth and Throat.—Erysipelas of the mucous membrane of the mouth and throat occurs, usually, as an extension from erysipelas of the face, less commonly as a primary infection. There is intense redness of the mucous membrane of the mouth and throat, marked swelling, and a danger of asphyxia from edema of the glottis. (See Erysipelas.)

Primary and Secondary Syphilitic Eruptions of the Mouth and Throat.—Primary and secondary syphilitic eruptions of the mouth and throat have been sufficiently described under Syphilis.

Gummata.—Gummata may occur in any portion of the mouth and throat. They are especially common in the tongue. They form submucous, or more superficial, nodules of varying size, which break down and leave characteristic gummatous ulcerations, with a punched-out and undermined border, and a base covered by necrotic material. They are more or less extensive and more or less destructive, according to the peculiarity of the individual case.

THE TONGUE

Congenital Deformities of the Tongue and Floor of the Mouth.—The most common deformity of the tongue is *congenital shortening of the frenum of the tongue*. When it is of a high grade it may lead to disturbances of speech. The mothers of infants are apt to overestimate the gravity of the condition, and to request an operation when none is required. When children have grown to be five or six years of age, and still are unable to speak plainly, it is sometimes assumed by the mother that the child is suffering from tongue-tie; whereas, often, the case is one of imperfect cerebral development. A congenital deformity sometimes occurs, such that the entire tongue is adherent, more or less firmly, to the floor of the mouth, as far forward as its tip. Cases have also been described in which the frenum of the tongue was too long, or, at least, the tongue was too movable, so that it fell back into the throat, and caused symptoms of asphyxia. The tongue may be *congenitally fissured*, and the fissure may be of any extent, from a slight furrow to a tongue completely bifid back to its base. The tongue may be abnormally long or abnormally large. (See Lymphangioma of the Tongue.) An *acquired atrophy*, usually of one side of the tongue, may result from intracranial hemorrhages in the region of the center of the hypoglossal nerve, or from tumors of the brain, cerebral syphilis, in the course of tabes dorsalis, progressive muscular atrophies, etc., or from division of the hypoglossal nerve.

Injuries of the Tongue.—The most frequent injury of the tongue is caused by the teeth. The tongue is often bitten during epileptic attacks, and a history

of such bites, and scars upon the tongue, is a diagnostic feature of epilepsy. A blow upon the chin while the tongue is protruded will produce a lacerated wound of the tongue. Further, sharp foreign bodies taken into the mouth with the food, stab and gunshot wounds of the tongue, are not infrequent. Wounds of the tongue are attended by free bleeding, and, if infected, by serious and even dangerous swelling. The bites of insects upon the tongue may also be attended by considerable swelling, usually of short duration. Burns of the tongue are caused by swallowing hot liquids, and are quite frequent as the result of swallowing caustic chemicals by accident, or with suicidal intent. Burns of the tongue produce, as upon the skin, hyperemia, vesication, or the formation of sloughs. The most frequent chemical burn of the tongue is produced by carbolic acid. The eschars during the first few hours are white, and the characteristic odor of carbolic acid can usually be detected. Foreign bodies may heal into the tongue or remain for years without producing any reaction (bullets, sutures, and the like) or they may cause abscess.

Inflammations of the Tongue.—The inflammations of the tongue occur as the result of infected wounds, from infection of burns of the tongue, as a complication of acute infectious diseases, and of severe stomatitis. Acute inflammation of the tongue usually runs a rapid course. The tongue swells rapidly, sometimes to twice or thrice is normal size, becomes more or less immobile, speech and swallowing are interfered with, the tongue may protrude from the mouth and become dry, there may be serious dyspnea. The condition is usually confined to one half of the tongue; it may end in resolution, or in suppuration and abscess. The presence of an abscess will be indicated by severe septic symptoms, high fever, a rapid pulse, localized pain and tenderness, sometimes fluctuation to be felt from the floor of the mouth, less commonly upon the dorsum of the tongue. The introduction of an aspirating needle also may demonstrate the presence of pus. After drainage the swelling and other symptoms usually subside very quickly. Fatal cases from general sepsis or aspiration pneumonia have occurred.

Tuberculosis of the Tongue.—Tuberculosis of the tongue is exceedingly rare as a primary infection, and occurs usually in persons with well-marked phthisis. In the cases I have seen the ulcer was situated upon the dorsum of the tongue near the tip; it was round, from a quarter to half an inch in diameter; the base was covered by a soft unhealthy granulation tissue, in which could be seen small caseating nodules; the ulcers were very painful. In some cases the ulcer may be deep and fungating. The base of the ulcers are not hard, as is the case with cancer; there may be secondary tubercles in the vicinity. A diffuse submiliary tuberculosis of the tongue may also occur.

Syphilis of the Tongue.—All three stages of syphilis may occur upon the tongue. *Chancre* of the tongue occurs upon the dorsum or sides of the front part of the tongue. It occurs as a sharply circumscribed nodular infiltration, more or less indurated, from a quarter to half an inch or more in diameter, and of a livid red color; induration may be more or less marked. After the

epithelial covering is lost the edges of the ulcer are slightly elevated, the center a little depressed, raw, and granular, or covered with a false membrane. The glands of the submaxillary region soon enlarge, and other symptoms follow.

Secondary manifestations are—during the early stages of the disease—mucous patches, already described. These occur especially at the tip and along the lateral borders of the tongue. They are usually accompanied by similar lesions of the inner surface of the lips, the corners of the mouth, etc. In severe cases true ulceration of the tongue may take place during the secondary stage. The ulcers are round, usually multiple, their edges are sharply marked, other manifestations are commonly present. Permanent scars, in the shape of fissures or puckerings upon the tongue, may follow these ulcerations. The *gummata* of the tongue are not uncommon; they usually form in the submucous tissue, and either break down, forming a craterlike ulcer of characteristic appearance and shape, or may be absorbed without ulceration. They are characterized by a slow course. They are firm or elastic, nodular in character, and relatively painless.

Syphilitic Sclerosis of the Tongue.—Gummata of the tongue may leave behind dense puckered scars and even notable deformity of the member. An interesting observation was made by me in a case of tertiary syphilitic ulceration of the tongue. The patient was a young man who presented himself with the history of repeated severe attacks of vomiting of blood. He was profoundly anemic. A probable diagnosis was made of ulcer of the stomach; further examination showed a deep tertiary syphilitic ulcer situated far back at the base of the tongue, just in front of the epiglottis, from which the hemorrhages had occurred. The ulcer healed promptly under specific treatment; the hematemesis did not recur.

Actinomycosis of the Tongue.—Actinomycosis of the tongue occurs as solitary or multiple nodules in the tongue, varying in size from the head of a match to that of a hazelnut. The nodules are in the anterior half of the tongue. For a long time the mucous membrane is adherent over them, but intact. They are moderately hard. They may ulcerate, and, if incised, they discharge a little pus containing actinomyces granules. The cavity of the abscess is filled with soft granulations, and there are apt to be little undermined pockets, here and there, communicating with it. The appearance is unlike the dirty-yellowish, shreddy, broken-down base of a gumma.

Infection and Inflammation of the So-called Lingual Tonsil.—Infection and inflammation of the so-called lingual tonsil, at the base of the tongue, is sometimes followed by abscess. The symptoms are those of an abscess of the back part of the tongue. It is especially likely to be followed by edema of the glottis.

Leukoplakia of the Tongue.—Leukoplakia of the tongue, regarded by many observers as identical with psoriasis, ichthyosis, keratosis, smoker's patches of the tongue, is a chronic disease characterized by the slow formation of opaque,

milk-white spots upon the surface of the tongue, less often upon the cheek, gums, and lips. Upon the tongue they form white, slightly uneven, or wrinkled, milk-white areas which appear to be slightly elevated above the general surface. There are often superficially ulcerated cracks and fissures crossing the white surface; they are confined to the anterior half of the tongue. The plaques are very sharply marked, of irregular contour; they are often multiple; they may cover a large part of the surface of the tongue. The cracks and fissures often bleed upon mechanical irritation. Upon palpation the diseased area feels quite hard. The disease is at first not markedly painful, but as time goes on the tongue becomes stiff, so that articulation may be troublesome. As the ulcers and fissures increase in number and depth, they become more and more sensitive, until eating and drinking becomes a torture. The disease is peculiarly interesting because many of the cases of carcinoma of the tongue are preceded by this condition of leukoplakia.

Tumors of the Tongue.—Angioma of the Tongue.—Angioma of the tongue occurs as angioma simplex and as cavernous angioma. *Angioma simplex* occurs in the form of small slightly elevated patches of a deep blue-red color, sometimes bright red, upon the surface of the tongue; less often they are more deeply seated in the substance of the tongue. They seldom exceed three fourths of an inch in diameter; they may be single or multiple, may remain stationary, or grow into tumors of some size. *Cavernous angioma* occurs in the form of single or multiple, blue or red nodules upon the surface, or in the substance of the tongue. They are sometimes erectile—i. e., they increase in size when the head is bent forward, upon coughing, straining, etc. They are soft and compressible like a sponge, and regain their size at once when the pressure ceases. They may also remain stationary or grow into pretty large tumors. There is always serious danger from hemorrhage due to slight accidental wounds and from infection.

Lymphangioma of the Tongue.—Lymphangioma of the tongue may be: (1) Simple; (2) cystic; (3) cavernous. Most of the cases of congenital and acquired enlargements of the tongue (*macroglossia*) are congenital *cavernous lymphangiomata,* or combinations of lymphangioma with hemangioma. The enlargement may be so great that the tongue cannot be retained in the mouth, and constantly protrudes through the lips. The enlargement may not be noticed at birth, or until the tongue is considerably increased in size. The protruded portion of tongue is of a deep-red color; and becomes fissured, excoriated, even ulcerated. A deep furrow exists at the line of the teeth. Speech, swallowing, and breathing are notably interfered with. Attacks of inflammation occur from time to time, and make the condition worse. *Cystic lymphangioma* occurs in the form of larger or smaller cystic nodules, simple or conglomerate, on the surface of or in the substance of the tongue, filled with clear or cloudy lymph.

Sarcoma of the Tongue.—Sarcoma of the tongue is a rare tumor, a few cases are reported. They possess certain definite peculiarities. They remain

often small and stationary for some time, and then grow rapidly. They are very painful, ulcerate early and deeply.

Cystic Tumors of the Tongue.—Small mucous cysts occur beneath the tongue, in the floor of the mouth, and in the mucous membrane of the cheeks as small, translucent, bluish, bladderlike elevations upon the surface, containing clear stringy mucus. Similar cysts may occur at the back of the tongue in connection with the lingual tonsil.

Ranula.—Mucous cysts of considerable size occur beneath the tongue and the floor of the mouth, to one side of the frenum, between the tongue and the jaw; they are very rare in the middle line. Ranula appears like a thin, rounded, pale-red, or bluish-white, translucent, bladderlike formation beneath the tongue, covered by normal mucous membrane, tense, but movable over the surface of the cyst. The contents are clear mucus closely resembling egg albumen; rarely the mucus is yellow or brown in color. A ranula may be (1) a cyst of Bochdalek's glands; (2) a cyst of the Blandin-Nuhn gland at the apex of the tongue; (3) a retention cyst of the sublingual gland or of the so-called glandula incisiva.

Dermoid Cysts.—Dermoid cysts of the floor of the mouth are congenital tumors, but may not grow to sufficient size to be noticed for some time. They present in the middle line of the mouth beneath the tongue, or beneath the chin; they are very rarely to one side of the middle line. They form globular or semiglobular tumors of elastic consistence. They may be mistaken for lipoma, or, possibly, for ranula. Their median situation and their contents establish the diagnosis.

Rare Tumors of the Tongue.—Lipoma is a rare tumor of the tongue. They are sessile, or pedunculated tumors of the dorsum, borders, or tip of the tongue. They may be embedded in the muscular tissue of the tongue itself. Other rare tumors of the tongue are fibroma, chondroma, osteoma. The so-called papilloma of the tongue is a small, sessile, or pedunculated tumor of the dorsum of the tongue, as large as a pea or a hazelnut. The surface is granular and rough. They are not painful, and rarely give rise to any symptoms. Some of the papillary outgrowths from the tongue are true benign epitheliomata, and resemble in structure the acuminate warts of the prepuce and elsewhere. A more massive fibrous tumor of very slow growth has occasionally been observed in the substance of the tongue. Endotheliomata of the tongue have been described as, for the most part, slow-growing tumors, showing hyaline and other forms of degeneration. Their diagnosis would be for the pathologist to make, after removal. Adenoma may occur as circumscribed nodular tumors of the substance of the tongue. Superficially they may resemble polypoid growths. The glandular tissue may resemble an acinous gland or the tissue of the thyroid gland—when they are known as *struma* of the tongue.

Cancer of the Tongue.—By far the most interesting and important tumor of the tongue is cancer. Even under the best of conditions it is one of the most painful and fatal of malignant diseases, and its early diagnosis is

therefore highly important. There seems to be no doubt that, in some countries at least, cancer is becoming more frequent; for example, in England, statistics seem to show that cancer of the tongue has become more than four times as frequent in the last twenty-five years. The disease is nearly ten times as frequent in men as in women. Cancer of the tongue arises in the tongue itself; in the mucous membrane of the cheek or of the floor of the mouth. Chronic irritations of the mucous membranes seem to play a very important part in the production of cancer of the tongue, and it has been supposed that the greater use of tobacco and of alcohol among men might account, in part at least, for the more frequent occurrence of cancer of the tongue in the male sex. The chronic irritation produced by the sharp borders of carious teeth is an exciting cause in a certain proportion of cases. Chronic syphilitic ulcers of the tongue are followed by cancer in some instances, and the same is true of tubercular and other chronic ulcerations. The disease is most frequent between the ages of forty-five and sixty-five; in a small percentage of cases it has occurred before the age of thirty.

The type of the disease is nearly always that of flat epithelial cancer. It begins either in the form of a papillary outgrowth, an indurated nodule in the substance of the tongue, a fissure, or as an ulcer. In all the forms, induration and early ulceration are prominent symptoms. In some cases, in addition to progressive ulceration and infiltration of the surrounding tissues, there are formed fungating papillary outgrowths of cancerous tissue, which may form ragged, uneven, warty-looking prominences of some size, suggesting in outline a cockscomb. The tumor tissue is characterized by hardness, by infiltration of the surrounding structures, and immobility. The base of the ulcerated surface is uneven, ragged, and fissured. The tumor, from the very start, has no sharply circumscribed boundaries; the induration gradually fades off into the surrounding tissues. The borders of the ulcerated area are ragged, elevated, indurated, and undermined. A necrotic inflammation develops on the raw surface early in the disease, giving it a dirty greenish-gray appearance. As in epithelioma of the lip, it is often possible to express from the raw surface epithelial-cell nests in the form of columns and pearls. In certain instances the disease may begin as a diffuse induration, or as a nodule, in the substance of the tongue, which only begins to ulcerate after it has reached the surface.

The further progress of the disease is characterized by putrefactive changes in the necrotic tissue and a stinking fetid odor. Marked salivation is usually present. Hemorrhages take place from the ulcerated surface spontaneously, or from slight mechanical irritation. Pain is a marked symptom; the pain is felt in the tongue and radiates toward the ear. As the disease advances, the neighboring structures are affected—the floor of the mouth, causing the tongue to become immobile, affecting deglutition and speech. The disease spreads to the gums, the cheeks, the palatine arches, and the tonsils. The lymph glands of the submaxillary region are very early involved. The disease also infiltrates

the lower jaw. If it extends toward the parotid region, the jaws may be firmly closed and the patient unable to open his mouth. Death occurs in from a year to a year and a half in unoperated cases—from exhaustion, hemorrhage, pneumonia, sepsis.

The diagnosis of cancer of the tongue is usually easy. It may, however, be confounded with syphilis, tuberculosis, actinomycosis, a benign papilloma, a pressure ulcer, caused by the irritation of a decayed tooth, and perhaps other conditions. In any case where the slightest doubt exists, a sufficient portion of the diseased tissue, including a little of the apparently healthy tissue of the vicinity, should be excised under cocain anesthesia, and subjected to a microscopical examination. The alveolar structure of the epithelioma, with its epithelial-cell nests and pearls, is so characteristic that the diagnosis of cancer can be made at a glance when they are present. Syphilis and tubercle are distinguishable by their histological characters, and tubercle also by the recognition of bacilli. It is to be remembered, in regard to cancer of the tongue, that a very early diagnosis is absolutely essential, so that immediate operation may give the unfortunate patient his only chance of cure.

THE PALATE, TONSILS, AND PHARYNX

Cleft Palate.—The various degrees of cleft palate, complete and incomplete, have already been described. Their recognition is, of course, entirely simple, and they require no further comment. Various defects of the hard and soft palate may occur as acquired conditions, especially from syphilitic ulcerations, less commonly from tuberculosis or from injury. They differ much in extent, situation, and character, and are recognizable upon inspection. Defects in the hard and soft palate always give the voice a nasal quality, and if the defect is extensive, the resonant tone of the normal voice is lost. The admixture of the contents of the nose and mouth constitute a disagreeable condition.

Injuries of the Palate, Tonsils, and Pharynx.—Injuries of the palate, the tonsils, and the pharynx are not very common. They occur most often when an individual falls upon his face while carrying some pointed object in his mouth—a lead pencil or the like—also from stab wounds, and quite often from suicidal gunshot wounds. They may be attended by sharp hemorrhage from the palate, and especially from the ascending pharyngeal artery, less commonly from the internal carotid. The pharynx is occasionally wounded by gunshot or stab wounds beneath the chin or at the side of the neck. I once saw a woman who had been wounded in the side of the neck by her husband, who used a carving knife for the purpose. The wound extended from in front of the ear to below the angle of the jaw, along the anterior border of the sterno-mastoid muscle. The knife divided the facial nerve and penetrated into the pharynx; the external carotid artery was plainly exposed in the wound—as in a dissection—but was not injured. The hemorrhage from this wound was moderate. The facial paralysis was permanent in spite of several efforts

to suture the nerve. In all wounds of the upper part of the pharynx there is danger of edema of the glottis, and serious or fatal dyspnea.

Foreign Bodies in the Mouth and Pharynx.—Foreign bodies of the most varied description may be taken into the mouth, either by accident or design, and become embedded in the tongue, the floor of the mouth, the palate, occasionally in the orifice of Steno's duct, or become lodged in the pharynx, or behind the palate, or above, in the posterior nares. Such bodies may be sharp, such as pins, fish bones, sharp fragments of bone contained in meat, or the like, or they may be blunt bodies, such as buttons or coins, or simply large masses of food or sets of false teeth. In the case of sharp bodies it quite often happens that the body slightly wounds the wall of the pharynx, the back of the tongue, or the upper part of the esophagus, but is really swallowed. If such is the case, it is usually safe, after a careful examination, to assure the patient that in all probability the foreign body will do no harm, especially if purgatives are avoided, and a diet of boiled potatoes, or the like, is prescribed. Bodies which are embedded in the tongue, the palate, the cheeks, or the posterior wall of the pharynx can usually be detected readily enough by direct inspection of the cavity of the mouth and throat, aided by daylight, the use of a tongue spatula, or by artificial light with a head mirror. The patient should be asked to phonate, when the muscular movements may bring the foreign body into view. The upper part of the nasopharynx can be examined by posterior rhinoscopy and palpation. In a large proportion of cases sharp foreign bodies get caught in the lowest position of the pharynx, or in the sinus pyroformis. They may be discovered by laryngoscopy or by palpation. Bodies caught in the sinus pyroformis are very apt to cause inflammation and edema of the glottis if they are not removed, and may cause an abscess only approachable by subhyoid pharyngotomy.

In case the body has passed down into the esophagus and become impacted, its presence can usually be detected by the passage of the esophageal bougie of the bulbous variety, or with the so-called "coin catcher." If the bodies are metallic and of sufficient size, they may often be detected by means of an X-ray picture. Large bodies—such as, for example, pieces of meat too large to pass through the esophagus—may cause immediate death by asphyxia when they occlude or engage in the orifice of the larynx. Sharp bones, pins, and other similar bodies, which are permitted to remain *in situ* in the pharynx or esophagus, may cause ulceration by pressure and serious hemorrhage, or they may pass into the trachea and cause death by septic pneumonia, or ulcerate into the pleura or mediastinum, with fatal results.

Acute Inflammatory Affections of the Pharynx and Tonsils.—The tonsils afford a frequent and favorable avenue for the entrance of bacteria. Many local and general infections are acquired through this channel. The mouth is the habitat of numerous and varied forms of bacteria, and while during robust health the pathogenic forms may be only slightly virulent, yet in conditions of local congestion, or catarrhal inflammation of the throat, they appear to acquire an

increased virulence. The various varieties of pyogenic cocci—notably the streptococcus, the pneumococcus, the diphtheria bacillus, and many other forms—may be found in the crypts of the tonsils.

The ordinary forms of tonsillitis may be divided into catarrhal, follicular, and parenchymatous tonsillitis.

Catarrhal Tonsillitis.—The simple catarrhal form is usually combined with a catarrhal pharyngitis which involves the posterior wall of the pharynx, the soft palate, and occasionally extends downward as far as the opening into the larynx, involving the epiglottis. The mucous membrane of the tonsils—usually both are involved—is reddened and swollen, and a similar intense redness is to be noted on the posterior pharyngeal wall and the soft palate. The local symptoms are a sensation of soreness in the back of the throat and pain on swallowing; the throat feels raw. In mild cases the patients may feel quite well, or there may be a little fever, chilly sensations, or even a chill, and some constitutional depression. In other cases, even where the throat is not intensely inflamed, the fever may be quite high; there may be severe headache, loss of appetite, pains in the muscles—notably at the back of the neck—and in the back, and marked prostration. In children there may be severe headache, sometimes delirium and convulsions. In the catarrhal form the general and local symptoms usually subside after three or four days.

Follicular Tonsillitis.—The inflammatory process in follicular tonsillitis is most marked in the walls of the follicles or crypts of the tonsil. One tonsil may be involved, or both, or first one and then the other. Upon looking into the throat, in addition to more or less marked general redness of the pharynx one or many of the orifices of the crypts of the tonsil are seen occupied by little white or yellow masses of exudate, consisting of epithelium, pus cells, bacteria, and granular detritus. There may be the production of considerable areas of false membrane upon the surface of the tonsil, which can sometimes be wiped away easily and sometimes not, but does not leave a distinct raw surface or loss of substance. The differential diagnosis from diphtheria is only possible by means of cultures from the throat. The presence or absence of diphtheria bacilli can thus be determined in twenty-four hours. The constitutional symptoms vary much in intensity and duration. There is often an initial chill, a marked rise of temperature, severe headache, notable prostration, etc. On the other hand, the general symptoms may be slight or absent.

Parenchymatous Tonsillitis.—The general symptoms are marked. Pain in the throat is severe; the tonsils are notably swollen; swallowing and speaking are painful; there may be inflammatory lockjaw. The process is often a forerunner of peritonsillar infection and abscess. In any of the forms of acute tonsillitis the lymph nodes at the angle of the jaw may be swollen and tender. In the more severe cases the patient is apt to hold his head rather stiffly, and turned a little to one side—a mild torticollis, involuntarily assumed, probably to relieve tension and pressure and to avoid motion of the tender throat.

Differential Diagnosis.—A syphilitic pharyngitis may simulate quite closely an ordinary acute tonsillitis and pharyngitis. It will usually be found that the syphilitic throat has come on more gradually, and has lasted longer before the patient consults a physician than is the case with ordinary attacks. *In early syphilitic pharyngitis an arch of redness extending completely across the soft palate above the uvula is thought to be characteristic.* It is to be remembered that in many cases of diphtheria the local lesion in the throat is by no means extensive or characteristic, and that cultures should be taken from the throat in all doubtful cases. Moreover, as indicated, many general diseases at the time of invasion—notably scarlet fever, measles, etc.—may present the local signs of pharyngitis and tonsillitis.

Herpes of Throat and Tonsils.—Herpes of the throat and tonsils occurs in the form of small vesicular spots. Almost at once they change to flat erosions, which soon are covered with false membrane, and may coalesce. They are surrounded by an inflammatory areola. Their simultaneous appearance on the face may aid the diagnosis.

Diphtheria.—Diphtheria often begins in one or more of the follicles of the tonsil. For the diagnosis the reader is referred to works on general medicine. Suffice it to say that the recognition of the characteristic growth and staining reactions of the bacilli are the means chiefly relied upon at present for a diagnosis, in cities at least.

Peritonsillar Abscess.—Infection of the tonsillar tissue with pus microbes causes abscess of the peritonsillar structures more often than abscess of the tonsil itself, although the abscess sometimes points on the surface of the tonsil. The formation of an abscess may be preceded by an attack of catarrhal or follicular tonsillitis, or begin independently. The signs and symptoms are constitutional and local. The general symptoms are those of a sharp invasion of sepsis, often a chill, a rapid rise of temperature, prostration, a rapid pulse, headache, etc. The local signs and symptoms are pain, of a severe, throbbing character, in the throat; difficulty and pain in swallowing, speaking, and even breathing. There is usually inflammatory lockjaw, more or less complete. Swallowing may become impossible; there will be drooling of saliva or frequent expectoration.

Inspection of the throat may be difficult. A general anesthetic and the use of a gag may even be necessary before the mouth can be properly opened. A marked swelling will be noted on one side of the throat. The pillars of the fauces and the tonsil are displaced toward the middle line; the tonsil is partly or entirely hidden by the swollen anterior pillar. The uvula is swollen and edematous. The anterior pillar, half the soft palate, and the mucous membrane—as far forward as the last tooth—are of a deep violet-red color. Palpation reveals a tender mass of induration—rarely fluctuation—the center of which often lies at the mid-point of a line connecting the base of the uvula with the last motor tooth of the lower jaw on the affected side. In most cases the abscess approaches the surface at this point; more rarely the pus lies pos-

teriorly and lower down, and is apt to rupture through the posterior pillar near the entrance to the larynx. In such cases the posterior pillar forms a ridge or prominence, which unites with the posterior pharyngeal wall.

The progress of the disease is rapid. The abscess usually evacuates itself, unless incised, in from three to ten days, followed by subsidence of the symptoms. If the abscess bursts posteriorly, the pus may flow into the larynx and cause dangerous dyspnea, or even asphyxia. In rare cases infection of the internal jugular vein may lead to pyemia. Cases of ulceration of the internal carotid artery and fatal hemorrhage have been reported. The pus may travel down the intermuscular planes of the neck and produce infection of the mediastinum. The glands at the angle of the jaw are usually swollen, and may suppurate. Infection of the pterygoid plexus of veins is possible, with sinus thrombosis and fatal meningitis. It is to be remembered that infection from the neighborhood of the last molar tooth may cause an abscess in the peritonsillar region identical in situation with that proceeding from the tonsil itself. A malignant tumor originating in the tonsil, of rapid growth, may cause appearances and symptoms not unlike a peritonsillar abscess, and in cases of doubt an exploratory puncture with an aspirating needle is desirable, since the incision of a malignant growth would probably be followed by serious hemorrhage. A chancre of the tonsil would present characteristic ulceration and induration, together with an absence of septic symptoms. Hard, enlarged, insensitive lymph nodes are present at the angle of the jaw.

Retropharyngeal Abscess.—Retropharyngeal abscess occurs, for the most part, during infant life and childhood. In babies it often results from infection of the retropharyngeal lymphatic tissue, complicating measles, scarlet fever, etc.; occasionally as the result of repeated attacks of tonsillitis; rarely following catarrhal inflammations of the nose and throat, or infections of the orbit or the ear. A subacute or chronic retropharyngeal abscess may follow tuberculous disease of the base of the skull, or of the bodies of the upper cervical vertebræ. The signs and symptoms of retropharyngeal abscess of the acute type are general symptoms of sepsis, and local symptoms due to interference with swallowing and with respiration. The interference is partly caused by the size of the pus sac in the back of the throat and partly due to inflammatory swelling of the mucous membrane, notably to edema of the larynx. The *diagnosis* is made by palpation of the back of the throat. In the early stages a tender, firm, or elastic mass can be felt projecting from or filling the posterior wall of the pharynx; later, fluctuation may be evident. The interference with breathing will produce noisy breathing, cyanosis, and other signs of dyspnea. The septic symptoms are apt to be predominant and grave. In little children, palpation of the throat affords far more information than does inspection. In the cases due to tubercular disease the signs and symptoms of sepsis will be absent. There will be interference with swallowing and dyspnea; a fluctuating swelling will be felt in the back of the throat on palpation. The chronic form of abscess is spoken of under diseases of the vertebræ.

Chronic Inflammation of the Tonsils. Hypertrophy of the Tonsils.—Chronic inflammation of the tonsils may follow repeated attacks of acute inflammation of the tonsils and pharynx; more commonly it is a condition noted especially in childhood, and associated with adenoid growths of the vault of the pharynx. The enlargement of the tonsils is easily recognized by inspection of the throat. The tonsils project on either side toward the median line, and more or less completely fill the back of the throat; they form rounded, more or less lobulated red tumors, with an uneven surface, upon which the orifices of the crypts of the tonsil are easily recognizable. In some cases the enlargement of the tonsils interferes seriously with respiration, and with the development and nutrition of these children. They are often mouth-breathers, and notably so at night, when they are apt to snore. They are often anemic; the expression of the face is dull, the eyelids droop, the nostrils are narrow, the voice is thick. The children are easily exhausted and put out of breath; slight exertion may bring on a violent fit of coughing, during which the child feels as though he had a foreign body in the throat which must be expelled. Speech and the sense of hearing, taste, and smell, are often impaired. There may be nervous symptoms, such as chorea and epilepsy. The enlargement of the tonsils is not infrequently combined with an arched palate, and occasionally with that deformity of the chest known as "pigeon breast." Chronic atrophic rhinitis may be associated with atrophy of the tonsils and an atrophic pharyngitis.

The Uvula.—Elongation of the uvula occurs as a congenital deformity—which, however, rarely produces symptoms during the early years of life; and as an acquired condition, from chronic pharyngitis the uvula may be too long, so that it irritates the base of the tongue and the epiglottis; a sense of tickling and irritation in the back of the throat may result, with a chronic throat cough and the habit of frequently clearing the throat.

Leptothrix.—Occasionally the tonsils become the seat of the growth of a fungus known as leptothrix; the base of the tongue may also be affected. The affected areas are dotted here and there with small plaques, of white or yellow material, composed of flat epithelial cells and masses of interlacing threads—the mycelium of the fungus—and fine granular matter representing the spores. The presence of the fungus does not usually give rise to any signs of inflammation.

Syphilis of the Tonsils and Pharynx.—*Chancre* of the tonsil is one of the most frequent sites of extragenital infection, both as the result of direct and of mediate contagion. Marked induration may or may not be present; there is a distinct tendency to rapid, sometimes phagadenic, ulceration. The initial lesion may thus be mistaken for a malignant growth of the tonsil. The cervical lymph nodes are markedly enlarged. The *secondary syphilides* occur upon the tonsil, in the form of mucous patches; the entire surface of the tonsil is frequently involved, and is covered by a white or pearl-gray film of exudate, surrounded by a red areola, often combined with a general pharyngitis. Syphilitic erythema of the pharynx and soft palate is one of the commonest lesions

during the early secondary stage. It has already been described. It does not materially differ from ordinary erythema in appearance, except that, as stated, an arch of redness crosses the soft palate, and there are frequently mucous patches also present. *Gummata* of the pharynx are notably common. They occur frequently in the soft palate, and may lead to perforation, or extensive destruction and scarring; if multiple, to a sclerosis of the muscular tissue of the palate. Disturbances of speech, a nasal voice, the regurgitation of food into the nose, difficulty in swallowing, and other disagreeable symptoms are the result.

Erysipelas of the Throat.—Erysipelas of the throat has already been mentioned. It is characterized, as already stated, by the local and constitutional symptoms of erysipelas, by a tendency to produce edema of the glottis, and to extend down the trachea and cause broncho-pneumonia.

Tuberculosis of the Pharynx, Tonsils, and Palate.—Tuberculosis of the pharynx, tonsils, and palate is extremely rare as a primary condition, and occurs for the most part as a complication of advanced tuberculosis of the lungs. It is, however, probable that the tonsils are the avenue of infection in many cases of tuberculous glands of the neck. The bacilli may pass through the tissue of the tonsil and infect the lymph nodes without producing any evident change in the tonsil itself; and it is believed that the removal of hypertrophied tonsils may prevent a recurrence of tuberculous glands of the neck after their operative removal. Tubercular ulcerations, if present, have the characteristic appearances. They occur upon the soft palate, pillars of the fauces, posterior wall of the pharynx, and tonsils. Larger or smaller nodules are formed in the mucous membrane, which break down and form ragged ulcers with cheesy degeneration of the bases; submiliary tubercles can be seen around the ulcer; the cervical lymph nodes are usually tuberculous. Tuberculosis rarely causes perforation of the soft palate, as does, so commonly, syphilis. Tuberculosis of the hard palate occurs as a slowly progressive tubercular caries, with final perforation. As compared with syphilis it is very infrequent.

Stenoses and Cicatricial Adhesions in the Pharynx.—The syphilitic tertiary ulcerations of the hard and soft palate and of the pharynx are sometimes extensive and destructive. During the healing process there may be adhesions formed between the posterior surface of the soft palate and the posterior pharyngeal wall, and also stenosis of the pharynx. Similar cicatricial contractions may follow burns and the ingestion of caustic liquids. In addition to strictures of the pharynx and adhesions between the soft palate and the pharyngeal wall there may be adhesions between the soft palate and the base of the tongue. The adhesions between the soft palate and the pharyngeal wall diminish, or less commonly entirely occlude the communication between the nasopharynx and the pharynx proper; as a result, speech is seriously interfered with in several ways. Moreover, these patients are usually obliged to breathe through the mouth, and have little or no sense of smell; they may also have serious difficulty in keeping the cavity of the nose clean. If, as often happens,

the closure is incomplete, and yet on account of cicatricial hardening of the muscles the opening between the nose and the pharynx cannot be completely closed, a portion of the liquids swallowed passes into the nose. The cicatricial strictures of the pharynx proper are of course never complete, else the patient would starve to death. They may, however, be quite narrow; swallowing may be difficult and speech is interfered with. Each case has, of course, a deformity peculiar to itself, and not difficult to recognize.

Varicose Veins.—Varicose veins occasionally occur in the pharynx and at the base of the tongue, and hemorrhage from these may lead to a diagnosis of bleeding from the stomach or from the lungs.

Tumors of the Palate, Pharynx, and Tonsils.—Among the tumors of the palate are fibroma, sarcoma, and occasionally dermoid cysts. Carcinoma of the hard and soft palate is nearly always due to the spread of a carcinoma from neighboring structures. Mucous polypi and papillomata, and occasionally adenomata, are observed. Some of the polypi consist of adenoid tissue resembling the structure of the tonsil; others are covered with horny integument and with hair. The hairs may be few and fine or thick and numerous, and quite long. These hairy polypi usually grow from the wall of the pharynx. They are regarded as teratomata by some observers, by others as dermoids. The papillomata are sessile or pedunculated, with a pedicle which grows longer with time. Cavernous hemangiomata sometimes occur in the soft palate. The angiomata, when of large size, are dangerous from accidental hemorrhage. Combinations with lymphangioma also occur. Fibroma, myoma, myxoma, lipoma, and sarcoma have been described as originating in the palate.

Mixed Tumors.—Mixed tumors may occur in the soft palate in various combinations. They contain cartilage, epithelial elements in the form of adenoma or epithelioma, fibrous tissue, and mucous tissue; there may be areas of sarcomatous round or spindle cells. These tumors sometimes occur alone, and sometimes are directly connected with similar growths in the parotid gland. They are benign tumors at first, but may undergo ulceration, and resemble closely a gummatous ulcer, with putrid decomposition and a fetid breath. They may also undergo carcinomatous degeneration. They form small solid or partly cystic tumors, and, if not ulcerated, are movable beneath the mucous membranes. Very rarely cystic tumors occur in the soft palate, lined with ciliated epithelium.

Tumors of the Tonsil.—The tumors of the tonsil are chiefly carcinoma and sarcoma. They are, generally speaking, rapidly growing and very malignant tumors, having the characters already described as appertaining to these new growths. They show an early tendency to ulceration. Their very early recognition is essential to any hope of cure. The surest method of diagnosis is the removal of a fragment of the growth for a microscopic examination.

Adenoid Tumors.—Adenoid tumors of the vault of the pharynx produce the symptoms already described under Hypertrophy of the Tonsils. Their presence is readily detected by palpation, less easily by posterior rhinoscopy.

They may be hard or soft, so large as to nearly fill the nasopharynx or so small as to produce no symptoms. They commonly grow from the vault, or top, of the pharynx, less commonly from the posterior wall, or from both situations.

The Fibrous Tumors of the Nasopharynx. Fibrous Polypus—Nasopharyngeal Fibroma.—These tumors grow chiefly from the fibro-cartilage, between the occipital and the sphenoid bones. They occur most often in males, between the ages of fifteen and twenty-five years. They are hard, fibrous tumors, covered with mucous membrane, and consist of bundles of fibrous tissue with few cells. When inflammation occurs in the tissue of the tumor, as often happens, and abundant round-celled infiltration, the dense, fibrous structure may be obscured and the microscopic appearances so changed that the tumor may be taken for a round-celled sarcoma. Although these tumors are so far benign that they form no metastases, yet, in their local destructive effects from pressure and rather rapid growth, in their spread into the nasal fossæ and the accessory cavities of the face, in their invasion of the cranial cavity, and other characters, they constitute a dangerous and often fatal disease. Beginning, as stated, in the base of the skull, these tumors grow downward into the upper pharynx. In some cases they reach only a moderate size, and then cease growing; in others they exhibit an extraordinarily active growth, and may recur after extirpation. They possess the peculiarity of invading the several cavities of the face steadily and progressively, and of causing the destruction or absorption of the normal structures in their path, chiefly by pressure.

The *early symptoms* observed are, first, obstruction of the nose upon one side, to which is added an increased secretion of mucus or muco-pus—the symptoms, namely, of nasal catarrh. The other nostril soon becomes plugged. The tumor advances into the nasal fossæ, and invades and occupies, one after the other, the accessory cavities of the nose—the antrum, the ethmoidal cells, sometimes the frontal sinus—and grows downward and backward into the pharynx. The walls of the bony cavities are gradually destroyed and absorbed by pressure. From the cells of the ethmoid they may, although rarely, invade the orbit. Penetration into the cranial cavity and the formation of an intracranial growth is not uncommon. After the tumor has reached a certain size, various deformities result. The skeleton of the nose is forced apart so that the nose is broadened and flattened. Absorption of the anterior wall of the antrum causes a bulging of the cheek. Invasion of the temporal fossa, a prominence in the temporal region above or below the zygoma. Interference with nasal breathing causes the patient to keep his mouth open. Exophthalmos results from invasion of the orbit. The symptoms of interference with the cranial nerves, notably with vision, are rare until the last stages of the disease, and are much more common in the case of malignant growths. One of the characteristic symptoms of the disease is hemorrhage, which proceeds from superficial ulcerations on the surface of the tumor, notably in the pharynx.

The hemorrhages may be moderate or severe; they are often repeated upon slight causes of irritation, such as coughing, sneezing, straining, etc., or they may occur spontaneously; they may be of a dangerous or even fatal character. Septic infection of the ulcerated surfaces of the tumor causes a purulent discharge, general symptoms of intoxication, sometimes a fetid breath.

The signs observed upon *inspection and palpation* vary with the age and size of the growth. The tumors may merely occupy a portion of the nasopharynx. More commonly the patient does not come under the observation of the surgeon until the tumor has reached a considerable size. The pharynx, and often the cavity of the nose, will then be found filled with a firm, dense mass; the surface, when viewed through the nose or by posterior rhinoscopy, may be white or bluish-gray or pink in color; large veins can sometimes be seen upon its surface. In the pharynx ulceration of the tumor surface is common. It will then appear yellow or brown in color, or covered with crusts. The tumor feels firm and elastic, and bleeds readily on mechanical irritation. Although the main tumor of the pharynx is often firmly packed into the pharyngeal vault, a little mobility upon palpation is not uncommon. The finger or a probe can sometimes be passed up behind the tumor, and its probable attachment to the base of the skull may be thus inferred. The differential diagnosis between fibroma of this type and malignant growths depends in part upon the age and sex of the patient, upon the absence of infiltration characteristic of sarcoma and carcinoma, upon the fact that the ulceration remains superficial, sometimes upon the recognition of mobility, sometimes only upon microscopic examination. In general, it may be said that, although these tumors grow rapidly, they do not grow as fast as the sarcomata, as a rule.

Tumors of the Lower Part of the Pharynx.—Very rarely *lipoma*, usually in the form of *lipoma arborescens*, may grow in the lower part of the pharynx, at or near the level of the rima glottidis. They may interfere with respiration by falling into the larynx. *Fibrous tumors*, often pedunculated, or even cylindrical in shape, may occur in the same situation. From the posterior wall of the pharynx there may grow fibroma, enchondroma, or mixed tumors, usually distinctly encapsulated and movable. From their size and situation they may cause obstruction to breathing or to swallowing. *Accessory thyroid glands* may occur in the same situation. *Epithelioma and carcinoma* may rarely arise from the posterior pharyngeal wall. I have seen two such cases; both grew from the posterior wall of the pharynx, at the level of the upper border of the larynx. One was a somewhat flattened ulcerated nodule, of about the size of an English walnut, which had caused pain and difficulty in swallowing, together with slight dyspnea. The patient was a woman of middle age; the tumor was an epithelioma of the flat epithelial-celled type. The second case occurred in a man fifty-two years of age, in the same situation. It was of about the same size as in the former case, but was a cauliflowerlike growth, which hung forward over the entrance to the larynx. Both tumors were reached without much difficulty through a subhyoid pharyngotomy.

These two cases were operated upon by Dr. Charles McBurney in the Roosevelt Hospital.

Sarcomata of several types have occasionally been observed in the same situation. *Carcinomata* may also develop, posterior to or to one side of the larynx. They are generally more or less circular tumors, surrounding the larynx, which soon invade the larynx itself. They are apt to cause early disturbances in swallowing, and are not easy to recognize except by deep palpation; an ordinary laryngoscopic view is not sufficient; sometimes an ulcerated surface can be observed behind the larynx. They are as a rule very malignant tumors, of bad prognosis. Carcinoma and sarcoma may occur in the vault and in the sides of the pharynx, especially in the tonsils. They give rise very early to serious disturbances, to ulceration, hemorrhages, a fetid breath, disturbances of breathing and swallowing. They are rarely recognized at a time when their operative removal is possible, except those tumors which arise in the tonsil itself.

CHAPTER XVII

INJURIES AND DISEASES OF THE EAR

THE EXTERNAL EAR

Congenital Defects.—Various congenital deformities occur in the external ear. They are, for the most part, easily recognized on inspection. Some of them may properly be mentioned. The entire pinna or auricle may very rarely be absent, or more commonly imperfect in one or other of its parts, or crumpled, or the ears may stand out at right angles to the head. The ears may be abnormally small or large; the latter condition is often combined with mental weakness, with criminality or idiocy. There may be two or more auricles. There may be stenosis, or atresia of the external auditory canal. Incomplete closure of the first branchial cleft may leave a fistulous tract, usually one half or three quarters of an inch in front of and above the tragus; occasionally in the lobule or in other parts of the ear. These fistulæ are usually not deep; they may, on the other hand, communicate with the pharynx. They commonly secrete a little yellowish fluid. Auricular appendages occur in front of the ear as small, sessile, or pedunculated masses of skin and fibrous tissue; they may contain a fragment of cartilage. The lobule of the ear may be fissured as a congenital condition or as the result of traction by heavy earrings.

Fig. 177.—Congenital Deformity of the Ear.

Injuries of the Ear.—Wounds of the ear, both subcutaneous and open and of all kinds, occur not infrequently. The vascularity of the ear is great, and such wounds heal, as a rule, rapidly and well. Severe contusions of the ear

may be accompanied by fracture of the cartilages and by hematoma of considerable size between the perichondrium and the cartilage. The hematoma forms a bluish red, fluctuating swelling, usually most prominent in the side of the ear next the head, less marked upon the outer, or concave, side of the ear. The blood in the former situation is, however, more rapidly absorbed, and therefore the latter remains longer. Infection of the hematoma may lead to purulent perichondritis and loss of portions of cartilage with crumpled deformity. Boxers, football players, and acrobats sometimes have this deformity (*fighter's ear*).

FIG. 178.—BOXER'S ENCHONDROMA (FIGHTER'S EAR). Photograph of J. F., pugilist, aged thirty-four.

The Insane Ear.—Among insane persons—notably those suffering from paralytic dementia, but also in other forms of insanity, and rarely even among healthy persons—a spontaneous hematoma may form in the external ear. The tumor forms in the course of a few days, sometimes with inflammatory symptoms. Subsequent enlargement and thickening or crumpled deformity of the ear results. Degenerative changes in the cartilages and atheroma of the blood-vessels are present in these cases.

Keloid.—The frequent occurrence of keloid in the lobule of the ear has already been noted under tumors. The condition is most commonly observed among negro women. (See Tumors.)

Perichondritis of the Cartilages of the Ear.—Perichondritis of the cartilages of the ear is a rare condition. It is attended by swelling of the ear, sometimes with pain, acute inflammation, and the formation of an abscess, more often not. If suppuration occurs, fistulous tracts often remain for many months.

Tumors of the External Ear.—*Angioma* occurs upon the ear as angioma simplex, or as a part of a cirsoid aneurism of the scalp. *Sarcoma* is rare. *Epithelioma* of the superficial or infiltrating variety is common. *Dermoid cysts* may occur either in front of or behind the ear, and *sebaceous cysts*, usually of the posterior surface of the auricle, are not rare.

Atresia.—Atresia of the external auditory meatus may be complete or partial; if congenital, it is usually associated with imperfect development of the organ of hearing. The acquired forms may be of any extent from a superficial ring-shaped contraction to complete obliteration of the canal; no special diagnostic signs can be given.

Wounds of the External Auditory Canal.—Wounds of the external auditory canal are not generally dangerous unless they involve the tympanic membrane or the posterior wall of the bony canal, or become infected. Fracture of the anterior wall, from blows upon the chin, has been spoken of under Dislocations of the Jaw, and, as was there stated, the condyle of the jaw has been driven upward through the bone, into the middle fossa of the skull, by extreme degrees of violence. Fractures of the posterior wall of the canal occur most often with fractures of the base of the skull through the middle fossa; the signs and symptoms have been fully described under Fractures of the Base. The diagnosis of fractures of the anterior wall of the bony canal is to be made from the history of a fall or blow upon the chin, the presence of hemorrhage from the external meatus, and the deformity, recognizable by examining the external auditory canal with a speculum or a probe, or both, after washing away the blood with sterile salt solution. Very serious and even fatal injuries may be caused by the accidental or intentional introduction of caustic liquids or of molten metal into the ear. The diagnosis is to be made from the history, from the very severe pain, from the evidences of a burn, or from inflammation, or the presence of a mass of metal together with a burn in the external auditory canal. If the material has entered the middle ear, there is usually, also, total deafness.

Furuncle of the External Auditory Canal.—Furuncle of the external auditory canal occurs as the result of digging in the ears with unclean instruments; as a secondary process following the discharge of pus from the middle ear, or without apparent cause. There may be but one furuncle, or a series of them occur, one after the other. When the furuncle is situated close to the external auditory meatus it may usually be seen without difficulty; when it is more deeply seated, the general swelling of the skin lining the canal is usually so great that it is hard to examine the deeper portions of the canal. The pain of these furuncles is extreme, and is of a throbbing, intense character, worse at night. Rupture of the furuncle is followed by a discharge of pus from the ear and relief of the pain, but other furuncles are apt to form, when the severe pain will return. A thorough examination of the ear of these patients with a speculum is practically impossible without a general anesthetic. Cocain has been, in my experience, ineffective.

Diffuse Inflammation of the External Auditory Canal.—Diffuse inflammation of the external auditory canal may occur of any degree of severity from a slight redness and swelling up to a severe phlegmonous inflammation, with involvement of the periosteum. A bad form of this condition is not infrequent in the course of diabetes, and a diffuse inflammation in this region should lead to an examination of the urine for sugar. If the tissues are greatly swollen, it will be impossible to introduce a speculum and examine the tympanic membrane, and thereby exclude inflammation of the middle ear. In some cases the swelling and redness will extend to the skin covering the mastoid process. The subjective symptoms of inflammation of the external auditory canal merely,

are pain, noises in the ear, and partial deafness; but unless the canal is entirely occluded by the swelling, the deafness will be much less marked than is the case with inflammation of the middle ear. The ear may be very carefully washed out with warm sterile salt solution, and if the deafness then disappears, inflammation of the middle ear is excluded. Swelling of the preauricular lymph nodes favors the diagnosis of inflammation of the external ear. Swelling of a lymph node over or behind the mastoid process indicates inflammation of the middle ear. Moreover, the swelling of the skin in otitis externa is more marked than that of the deeper tissues; the groove between the ear and the mastoid process is often obliterated. Periostitis of the mastoid process is accompanied by swelling of the periosteum rather than of the skin. The groove usually remains discernible. The phlegmonous variety of inflammation may be attended with severe septic symptoms, involvement of the periosteum and bone, sinus phlebitis, meningitis, and pyemia.

Accumulated Cerumen (Ear Wax) in the External Auditory Canal.—Accumulated cerumen in the external auditory canal may cause partial deafness if it entirely fills the caliber of the canal, ringing in the ears, a sensation of itching, of a foreign body in the ear, sometimes giddiness. These plugs of wax can sometimes be seen as dark-brown, almost black, masses by placing the patient so that a strong light falls into the ear, and by drawing the external ear upward, outward, and backward, or by the introduction of an ear speculum, and illuminating the interior of the ear by natural or artificial light reflected into the ear from a suitable concave mirror.

Foreign Bodies in the External Ear.—Foreign bodies of the most varied description may be introduced into the external auditory canal, either by accident or design. The majority of these patients are children. The bodies usually remain, if let alone, in the cartilaginous portion of the canal, unless, as is rarely the case, they are maggots, fleas, flies, or other live creatures, which may find their way beyond the narrowest portion of the canal at the junction of the cartilaginous and bony sections. Unskillful efforts at removal may cause wounds of the tympanic membrane; or the foreign body may be forced into the middle ear. The presence of a foreign body may cause no symptoms at all; or, if it rests against the tympanic membrane, it may cause ringing in the ear or giddiness; if it fills the canal, it will cause partial deafness. In some cases a foreign body, if infected, may cause inflammation, attended by pain, swelling, and a discharge from the ear. The presence of insects, if alive, will cause noises in the ear, sometimes pain and giddiness. The presence of a foreign body in the ear is determined by inspection, either direct or through a speculum. The diagnosis is usually not difficult.

TYMPANIC MEMBRANE

Injuries of the Tympanic Membrane.—The tympanic membrane may be injured by direct or indirect violence. The injuries from direct violence are

caused by the introduction of sharp-pointed instruments into the ear—sharp sticks, etc.—or occur from unskillful efforts to extract foreign bodies. The injuries by indirect violence are caused by blows and falls upon the head, by sudden changes in the atmospheric pressure in the external auditory canal, as from a box on the ear, diving in deep water, working in caissons, fractures of the base of the skull, the near discharge of large cannon, etc. The symptoms and signs of rupture of the tympanic membrane are partly subjective and partly objective. The subjective symptoms are pain in the ear, sometimes giddiness, sometimes faintness and vomiting; there is partial deafness. If the injury has been caused by direct violence, the labyrinth may be injured.

The *symptoms of injuries of the labyrinth* are sudden marked giddiness, nausea, and vomiting. At the moment of the injury the patient usually has the subjective sensation of a loud sound. The symptoms of cerebral shock are often present. The subsequent symptoms are giddiness, difficulty in maintaining equilibrium, sometimes a staggering gait. The patient grasps surrounding objects to steady himself, and for several weeks may suffer from vertigo and nausea, whenever he tries to stand or sit up. In injuries of the labyrinth deafness will be marked, and is usually complete in the affected ear.

The immediate diagnosis of *ruptures of the tympanic membrane*, while it may usually be inferred from the history, the bleeding, and other signs and symptoms already described, is not always capable of verification. The external auditory canal is usually filled with a mixture of fluid and clotted blood, and the tympanum cannot be inspected until this is removed. It would be unwise under these conditions to clear the canal with a syringe and warm water, because of the danger of forcing infectious material into the middle ear. The blood may, however, be gently wiped away with small pieces of sterile cotton or gauze. The ear drum, when exposed, will often show extensive ecchymosis into its substance. The seat of the rupture will appear as an ecchymotic spot, or streak, in the membrane, or there may be a ragged tear filled with blood clot. The membrane near the rupture will be the seat of ecchymosis, more or less widespread. The rupture may be in any part of the membrane, but is more commonly in the lower half. There is usually but one perforation, although there may be several. Ruptures by indirect violence are rarely followed by infection. Those caused by direct violence with unclean instruments may be followed by suppurative inflammation of the middle ear.

The medico-legal question is sometimes raised as to whether deafness, following an injury to the ear, is due to the accident itself, or to antecedent disease of the ear. This question can sometimes be answered, very often it cannot. If the patient can be examined soon after the alleged injury, ecchymosis in the tympanic membrane, and the absence of the signs of a chronic inflammatory lesion of the middle ear, speak for a traumatic origin. An extensive well-rounded loss of substance in the tympanic membrane, with thickening, a purulent discharge from the ear, will point rather to antecedent disease of the middle ear. Infection may, however, have followed the injury, and in many cases it will

be impossible to say whether or not the condition is due to the accident or to antecedent disease.

EXAMINATION OF THE EAR

Although the diseases of the ear are, at the present time, almost exclusively in the hands of specialists, a brief description of the methods used in examining the ear seems necessary in this place. The methods of examination are: By direct inspection of the external auditory canal; inspection of the canal and of the tympanic membrane through a speculum (otoscopy); catheterization of the Eustachian tube; further, the procedures of Politzer and Valsalva; the diagnostic auscultation of the ear with the auscultation tube; finally, testing of the hearing.

Direct Inspection of the External Auditory Canal.—The examination of the external auditory canal is conducted by daylight or by artificial light. Daylight is preferable because the normal color of the tympanic membrane—a pearl gray, with a tinge of blue—is perceived; by gaslight or electric light, it appears yellow, with a tinge of red. A head or hand mirror, concave, perforated at the

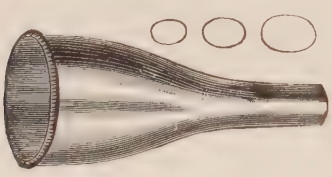


FIG. 179.—GRUBER'S AURAL SPECULUM.

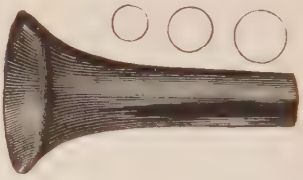


FIG. 180.—POLITZER'S HARD-RUBBER AURAL SPECULUM.

center, and two inches and three fourths in diameter and a focal distance of six inches, is generally used to cast reflected lights into the ear. The mirror may be held in the hand, or an ordinary laryngoscopic head mirror may be substituted, and worn on the forehead; or one or other of the small electric headlights in common use may be used, if convenient. The source of illumination may be daylight—preferably with a northern exposure; a bull's-eye with an Argand burner; or an electric-light bulb; or the electric headlight, as stated. Direct sunlight is undesirable.

Inspection of the Canal and of the Tympanic Membrane through a Speculum.—Two varieties of specula are in common use—that of Gruber, made of metal and elliptical on section, and that of Politzer, made of hard rubber and circular on section. They are made usually in three sizes. Further, in order to determine the mobility, and some other qualities of the tympanic membrane, some modification of Siegel's pneumatic otoscope, or Brunton's otoscope, may be used. These instruments consist, essentially, of a small air-tight box of hard rubber or metal attached to an ear speculum. The interior of the box is connected with a rubber tube and hand bulb. In one side of the box there is a glass window or lens. The speculum of the apparatus being introduced into

the external auditory canal, the surgeon may examine the tympanic membrane through the window, and by means of the hand bulb connected with the apparatus the air-pressure upon the membrane may be increased or diminished, causing it to move back and forth, and become more concave or convex, as the case may be. Its degree of mobility, normal or abnormal; the presence of adhesion; of atrophy; rigidity, etc., may thus be noted under the control of the eye. A good instrument of this kind is now made by the "Electro-Surgical Instrument Company," of Rochester, N. Y. In order to insert the ear speculum properly the canal must be made straight by drawing the external ear upward and backward; a speculum of suitable size is then inserted very gently into the canal, until it has passed the junction of the bony and cartilaginous portions, when it will sometimes stay of itself; or the surgeon may continue the traction upon the auricle, upward and backward, with the third and fourth fingers of his hand, while holding the speculum between his forefinger and thumb.

If the ear contains epithelial masses or wax, which obstruct the view, they must be washed out by a stream of warm sterile salt solution or boric acid, directed obliquely upward against the wall of the canal by means of a large hand syringe. The washing must be done gently, else the patient may suffer from giddiness, or even faintness. The ear is then carefully dried with bits of sterile cotton or gauze, held in the angular ear forceps, and the speculum reinserted. Very hard plugs of wax sometimes resist efforts to wash them out. If the operator is skillful, such may be removed by a scoop, curette, or forceps. If not, it is best to soften the plug by dropping into the ear a warm saturated solution of sodium bicarbonate containing a little glycerin. Repeated applications may suffice in the course of half an hour to soften the plug sufficiently so that it can then be washed away. In some instances it may be necessary to leave the alkalin solution in the ear overnight protected by a plug of cotton.

The normal eardrum is, as stated, of a pearl-gray color when viewed by daylight, with a slightly bluish cast. By artificial light it appears reddish-yellow. The circumference of the eardrum is marked by a white line. In the upper half of the membrane, extending from in front, downward and backward, to the middle, is seen the so-called "handle" of the malleus; its short process is seen as a white prominence near the upper and anterior border of the membrane. In the lower and anterior quadrant is seen a bright cone-shaped area of reflected light, which extends from the center of the eardrum, downward and forward, nearly to its border. The surface of the membrane is not normally a plane, but exhibits several folds and cavities. On account of its oblique position, and of the concavities, the posterior and upper portion is viewed obliquely; the anterior and lower portion is more at right angles to the line of vision. The eardrum is of varying degrees of transparency, both in health and disease. Above the short process of the malleus there is a small area known as Shrapnell's membrane, or the flaccid portion of the eardrum. It leads into, or forms a part of, the floor of the space known as the epitym-

panum. In examining the tympanum its color should be noted, whether it is translucent or thickened; whether there are localized opacities or chalky deposits; whether the membrane bulges, from fluid in the middle ear, or is retracted. If retracted, the short process of the malleus will appear more prominent, the long process will appear foreshortened, and the conical depressions or folds, in front of or behind it, will appear deeper, and the light cone may be displaced or changed in shape. In order to determine the mobility of the membrane, Siegel's pneumatic otoscope may be used, or one of the more recent modifications of this instrument.

Methods of Testing the Hearing.—In order to test the acuteness of hearing the ticking of a watch may be used. The ears should be alternately stopped by putting the index finger in the meatus, and the distances at which the patient ceases to hear the watch in each ear may be alternately tested and compared; or, the voice, either in whispered or spoken words, may be used in the same way. The tuning fork may be used to determine whether the disease is in the conducting apparatus of the middle ear, or in the organ of hearing in the labyrinth. For this purpose a small tuning fork, usually in the key of "C," vibrating five hundred and twenty-eight times a second, is set vibrating and held close to the ear. Under normal conditions the note will be heard louder and longer in this way than when the base of the fork is placed in contact with the mastoid process—that is to say, the aërial conduction is better than the bony conduction. In deafness arising from the auditory canal or from the middle ear, the tone will be heard louder and longer when the fork is placed in contact with the skull. When bone conduction is lost, it indicates that the organ of hearing in the labyrinth is at fault, and the same is true when the hearing, *though imperfect*, is better by aërial than by bone conduction. If the handle of the fork is introduced into the external auditory meatus of one side, and the patient hears the vibratory note only in the opposite ear, we may be sure that the organ of hearing of the ear in which the tuning fork is placed is destroyed.

Schwartze gives this among other methods for detecting simulated deafness: The healthy ear is plugged with cotton or with the finger; if, then, the patient states that he does not hear loud, or moderately loud, spoken words, he exaggerates, or does not speak the truth. The tuning fork may be used in a similar manner; the sound ear may be stopped with the finger, and the tuning fork placed anywhere upon the skull; if, then, the patient says he hears nothing, he is simulating. It is a good plan in making the various tests of hearing to request the patient to keep his eyes closed.

Tests of Bony Conduction (*Weber's Test*, *Rinne's Test*).—Tests of bony conduction of sounds may be made with a watch or a tuning fork. In normal cases, if the external auditory meatus be stopped on both sides with the finger tips, and a watch be placed in contact with the mastoid process, the teeth, or the temporal region, the ticking of the watch will still be perceived. In cases of partial deafness a positive result of this experiment indicates that sound

perceptions in the labyrinth are still present, although not necessarily perfect. Should the results be negative, we cannot conclude, from this sign alone, that the acoustic nerve is paralyzed; since, in persons over fifty years of age and in some intermittent functional disturbances of hearing, the watch may not be heard, although the hearing may be practically normal (Politzer). The diagnostic value of the experiment is chiefly this, that if an individual is notably deaf for sounds transmitted by aërial condition, and still hears the ticking watch placed in contact with the skull plainly, he is probably suffering from deafness due to a disorder of the conducting apparatus. If the result of the experiment is negative—i. e., the ticking not perceived by bony conduction and the patient is young—it indicates a serious disturbance of hearing, and is therefore of rather unfavorable significance (Pollak).

Weber's Test.—If a vibrating tuning fork is placed in contact with the skull of an individual with normal hearing, the tone will be either heard in both ears alike or referred to the point of contact of the fork with the skull. If, now, one ear be stopped with the finger, the sound will at once be heard in that ear. "*Weber is lateralized on the side where an obstruction exists in the conducting apparatus.*" If one ear after the other be stopped, or one more firmly stopped than the other, the tone will always be heard more distinctly in the ear where the greater obstruction exists in the conducting apparatus. Weber's test is especially valuable in differentiating between affections of the sound-conducting and the sound-perceiving mechanisms. If deafness in one ear exists, and the tone of the fork is heard by bony conduction more distinctly in that ear, a defect in the conducting apparatus of that ear is surely present. When partial deafness is present in both ears, and the fork is heard more distinctly in the worse ear, the same conclusion can be drawn. In case one ear only is deaf, and Weber's test is lateralized in the sound ear, a conclusion of disease of the sound-perceiving apparatus (acoustic nerve) can only be drawn in the presence of a positive Rinne's test, and some other conditions which will probably require the expert judgment of an ear specialist to interpret correctly.

Rinne's Test.—If a vibrating tuning fork, best of large size and low pitch, is placed upon the mastoid process of an individual with normal ears, the tone will be heard for a certain time, and gradually cease to be perceived. If, now, without striking the fork again, it be removed from the bone and its tines be held close to the external auditory meatus, the sound will again be perceived for a certain time. The result of the experiment is positive. "Positive Rinne"—i. e., the sound is heard longer by air conduction than by bone conduction. In many cases of disease of the conducting apparatus the test will be negative. The tone will be heard longer and better by bone conduction than by air conduction. The fork removed from the bone and placed near the ear is not heard, "Negative Rinne." The diagnostic value of Rinne's test has certain limitations. If the test is negative, the more the efficiency of bone conduction exceeds that of air conduction, the greater the likelihood of disease of the conducting

apparatus. A positive result, on the other hand, makes a defect of the acoustic nerve probable only when sound perception by bone conduction is very greatly decreased, and other signs and symptoms point to disease of the nerve (Pollak).

It is found that disturbances of the conducting apparatus are more apt to cause deafness for low notes. Such deafness is common in acute and chronic inflammation of the middle ear. Affections of the acoustic nerve are apt to cause deafness for high notes. These facts are utilized in diagnosis by using a series of tuning forks ranging from a low to a high pitch, and Galton's whistle.

Catheterization of the Eustachian Tube.—Catheterization of the Eustachian tube is used to determine the permeability of the tube—i. e., whether a free communication exists between the pharynx and the middle ear; to determine the mobility of the tympanic membrane; to detect the presence of exudates of various kinds in the middle ear; and, sometimes, to detect the presence of perforations of the tympanic membrane. The therapeutic uses of the Eustachian catheter do not concern us here. Eustachian catheters are made in several sizes, of hard rubber or metal. The catheter is inserted into the orifice of the Eustachian tube through the nose by one of two methods.

First Method.—The patient's head should be supported by the back of a chair or the wall. The catheter is held lightly between the finger and thumb, near the handle, with the beak directed downward. The surgeon sits or stands in front of the patient, places the fingers of his empty hand upon the patient's forehead, and with his thumb elevates the tip of the nose, so as to bring the opening of the nostril above the level of the floor of the nasal cavity. The catheter is then very gently pushed, beak downward, backward along the floor of the nose, until it touches the posterior pharyngeal wall. It is then withdrawn until the beak comes in contact with the posterior surface of the soft palate. By means of the handle, the beak is then rotated upward and outward, until the ring on the handle points to the outer canthus of the eye on that side. The point should then be at the orifice of the Eustachian tube, in which it should readily engage. Its introduction is sometimes aided by asking the patient to swallow. If the catheter is in the tube it is firmly held, and can be neither rotated nor pushed forward. Swallowing movements should cause the catheter to move, but speaking and swallowing should not be interfered with by the presence of the catheter. Moreover, the injection of air through the catheter, by means of Politzer's bag, should be distinctly felt by the patient to distend the middle ear, and by the use of the auscultation tube the surgeon should hear it also.

Second Method.—The catheter is introduced through the nose, as before, until the beak comes in contact with the posterior wall of the pharynx. The beak of the catheter is then rotated toward the opposite side of the pharynx until it is horizontal. The catheter is then withdrawn until a sense of resistance is felt as the curved beak comes in contact with the septum of the nose; the catheter is then rotated so that its beak passes through a little more than

a semicircle, at first downward, and then upward, toward the orifice of the Eustachian tube, until the ring on the handle is directed toward the outer angle of the eye. The beak is then in position to enter the Eustachian tube. In the presence of marked deformity or narrowing of the nasal fossa, or of tumors, adenoid growths, or other, in the pharynx in children, in acute inflammations of the Eustachian tube, in the nervous and hysterical, and, in some instances, where the operation is followed by coughing, retching, etc., the introduction of the catheter is difficult or impracticable.

Politzer's Method of Testing the Eustachian Tube.—Another method of determining the permeability of the Eustachian tube and of inflating the middle ear is by means of Politzer's bag. The instrument consists of a soft-rubber bag about the size of a man's fist, with a hole on one side, which can be closed by the finger. A soft-rubber tube is attached to the bag and has a hard-rubber nozzle at the end of it for insertion into the nose. In conjunction with this apparatus the auscultation tube is useful. It consists of a piece of soft-rubber tubing of suitable length, into either end of which is inserted a hard-rubber nozzle of such size that it fits tightly into the external auditory meatus. When the middle ear is to be inflated by the Eustachian catheter or the Politzer's bag, the surgeon introduces one of the nozzles of the auscultation tube into his own ear and the other into the ear of the patient. The surgeon can then plainly hear the normal and pathological sounds produced when air enters the middle ear of the patient.

Fig. 181.—Politzer's Air-Bag.

Politzer's bag is used according to the directions of its inventor in the following way:

The patient, seated in a chair, takes a little water in his mouth, which he is required to swallow when told. The surgeon, standing on the patient's right, introduces the nozzle of the Politzer bag (see Fig. 181) 1 cm. into the corresponding nasal orifice, and then compresses with the left thumb and forefinger the alæ of the nose closely around the instrument. The patient is next told to perform an act of swallowing, and at the same moment the surgeon expels the air from the inflating bag with his right hand. By the condensation of air produced in the nasopharynx in this manner, the closure effected by the soft palate is forced open, and its vibrations give rise to a dull, gurgling sound, which frequently, if not always, may be taken as an indication that the air has entered into the middle ear. The majority of the patients experience at the same time the subjective sensation of a current of air entering both tympanic cavities.

Valsalva's Method of Inflating the Middle Ear.—The patient stops his nostrils by pinching his nose between his finger and thumb, closes his mouth, makes an expiratory effort, and at the same instant swallows. The act of swallowing tends to relax, or to open the Eustachian tube, and air under pressure is, under normal conditions, forced into both middle ears. If the effort is successful, the patient hears a fairly sharp snap in both ears, and feels a sense of distention. The sounds heard by the surgeon under pathological conditions with the auscultation tube as air enters the middle ear are of a varied character, and their pathological significance can hardly be learned except by considerable practice. Normally, the air may be heard to enter the middle ear with a sharp, clean-cut popping, or friction sound. If the ear is filled, or partly filled, with an exudate, the character of the sounds heard will vary with the physical quality of the exudate. If it is thin and watery, the sound will be a fine bubbling; if the exudate is thick and viscid, a coarse bubbling sound will be heard; if the exudate is very thick or dry, the sound will resemble the friction sounds of dry pleurisy. If the eardrum is perforated, a characteristic squeaking or whistling sound will be produced. Many of the diseases of the ear require such special skill for their recognition that their diagnosis is not likely to interest the general surgeon, and only those diseases of the ear which properly belong to general surgery will be here considered.

THE MIDDLE EAR

Acute Suppurative Inflammation of the Middle Ear.—Acute suppurative inflammation of the middle ear occurs as the result of infection of the mucous membrane of the middle ear with one or other of any of the bacteria capable of causing suppuration. The disease is especially frequent as a complication of the acute exanthemata in children, and may follow infected traumatisms of the tympanum, erysipelas, diphtheria, syphilis, influenza, pneumonia, typhoid, or typhus fevers. It also may follow acute or chronic naso-pharyngitis, tonsillitis, etc. The middle ear becomes acutely inflamed and filled with an exudate of a muco-purulent or purulent character.

The diagnosis of the disease is made from the symptoms and signs. The *symptoms* are a feeling of fullness and distention in the ear, which follows immediately upon the inflammatory closure of the Eustachian tube. There are ringing or buzzing noises in the ear. There may be giddiness or vertigo. There is deafness more or less complete. Pain, at first dull, then sharp and severe and throbbing. In children there is often fever. There may be facial paralysis. There may be tenderness over the mastoid process. The deafness may be of any grade. The tuning fork shows that aërial conduction is diminished, bone conduction is present, and often increased in the affected ear—i. e., Weber's test is lateralized in the affected ear. If the labyrinth becomes infected, bone conduction is lost. The disease may involve the mastoid antrum, the petrous portion of the temporal bone, and cause pachymeningitis, menin-

gitis, sinus phlebitis, pyemia, with their characteristic signs and symptoms, as described in another place. In bad cases a fatal result may occur in this manner in two or three days from the commencement of the attack. In the ordinary cases examination of the tympanic membrane shows hyperemia of the eardrum, at first localized behind the manubrium, soon becoming general; followed by dullness and opacity of the entire membrane. As the amount of exudate increases the membrane bulges outward, usually more prominently at some particular point, and, if unrelieved by operation, perforation of the eardrum usually takes place at the point of greatest bulging, in two, three, five days, or longer. After the rupture of the eardrum the pain usually subsides; there is a discharge of pus from the external ear, and, generally, a relief of all the symptoms.

In little children the symptoms first noticed are chiefly those of pain and of tenderness in the region of the ear. They are apt to cry out loudly when the ear is disturbed or washed. They also exhibit very marked constitutional symptoms of infection. They may have high fever, intense headache, stupor, and even unconsciousness and general convulsions; all of which are quickly relieved by puncture of the tympanic membrane, or a rupture of the eardrum of such size that the pus has a free outlet. If the perforation is small, the symptoms may diminish in severity, or get better, and again grow worse if the outlet is closed, or drainage imperfect. After the rupture or incision of the eardrum the discharge from the ear usually becomes thicker and more viscid, and after a few days changes to a muco-purulent character, and finally to mucus, after which it ceases. The healing of the perforation in the drum membrane takes place slowly; in favorable cases in about three weeks. In some cases the acute inflammation leaves behind permanent changes in the eardrum, and the structures of the middle ear of a hypertrophic or sclerotic character, and permanently impaired hearing. If the pain, fever, and other constitutional symptoms continue, or grow worse, after a free discharge of pus has occurred through the tympanic membrane, it indicates probable involvement of the bone, or mastoiditis, or infection of the interior of the skull. These serious complications are, however, relatively infrequent as the result of acute inflammation of the middle ear; they are much more common as a complication of the chronic form.

Chronic Inflammation of the Middle Ear.—Chronic inflammation of the middle ear follows the acute form of the disease in a considerable proportion of cases. Depressed states of health, imperfect drainage, delayed or imperfect operation, involvement of bone, the formation of granulations in the middle ear, favor, or cause, the continuance of the inflammation. Middle-ear disease complicating scarlet fever seems peculiarly liable to assume a chronic form. The disease is characterized by a chronic purulent discharge from the ear, and by the presence of a perforation in the eardrum visible on inspection. The perforation may be of any size and shape, either quite small, or practically the entire eardrum may be destroyed. The symptoms are: Deafness, which

may be moderate, or very marked; there is usually little or no pain until the occurrence of some acute inflammatory complication; subjective sensations of noise in the head are the exception rather than the rule. In case the outlet for the pus becomes closed, or from an acute inflammatory exacerbation, symptoms will be produced resembling those of acute inflammation of the middle ear.

The importance of chronic inflammation of the middle ear lies in the frequent occurrence, even after the disease has existed for many years, of inflammatory complications involving the cellular cavities connected with the middle ear, especially the mastoid antrum and the mastoid cells; further, the danger of purulent infection of the bony walls of the middle ear followed by periostitis, ostitis, and necrosis; the likelihood of caries and necrosis of the ossicles of the ear; the spread of the disease to the labyrinth; suppurative inflammation of the petrous portion of the temporal bone, with involvement of the venous sinuses of the cranium; and, finally, disease of the brain and its membranes.

Diagnosis of Chronic Middle-ear Disease.—The diagnosis of chronic middle-ear disease is not usually difficult. If the discharge is profuse there will often be fissures, eczema, or ulcerations in the neighborhood of the external auditory meatus. After washing out the discharge from the ear, granulations will sometimes be seen in the deeper part of the canal. The speculum is used to examine the eardrum. The perforation is usually single; varies in size from that of a needle puncture to loss of the entire membrane. It is most commonly situated in the anterior lower quadrant, less often in the posterior upper quadrant; infrequently it will be found in the anterior upper quadrant or in the membrane of Shrapnell. The shape of the perforation is round, oval, or, when it embraces the handle of the malleus, kidney-shaped. It may be angular and irregular. The edges are smooth, thickened, or covered with granulations. The membrane may be retracted and adherent to the bony wall of the middle ear. If the perforation is large the mucous membrane of the middle ear may be seen, smooth, white or red, or velvety, or covered with granulations and rough. The entire middle ear may be filled with granulations or with cholesteatomatous masses. There may be small granulating areas overlying exposed or carious areas of bone, recognizable as such by the characteristic grating sensation transmitted through a probe. It may be possible to recognize the ossicles covered with discharge, or carious. The perforation or the entire cavity of the middle ear may be filled with white or yellow crumbly masses of desquamated epithelial cells, mixed with cholesterin and fat crystals (desquamative inflammation of the middle ear)—cholesteatomatous masses. The discharge often has a pungent, rancid, or putrid odor.

Perforations of the membrane of Shrapnell are often hard to discover on account of granulations or epithelial plugs. The passage of the Eustachian catheter and inflation of the middle ear usually permits the surgeon to hear the characteristic sound. The perforation may sometimes be further demonstrated by putting some light powder—such as lycopodium or boric acid—in

the external auditory canal, and blowing air into the middle ear through the catheter. The powder may thus be forced out of the external ear as a little cloud. The varied appearances of the interior of the middle ear require considerable skill and practice in the use of the otoscope for their recognition and interpretation; they can only be briefly mentioned here.

Chronic inflammation of the middle ear may get well either with or without treatment. The tendency of the disease is, however, to continue indefinitely, sometimes getting better, sometimes worse, the symptoms varying with general and local conditions of health and environment. Sooner or later, as the result of imperfect drainage, a catarrhal attack, an influenza, or from the slow or sudden involvement of some new area of bone or mucous membrane by an extension of the infection through continuity of structure, one or other of the dangerous complications of middle-ear disease arises and puts the life of the individual in peril. The diagnosis of these complications will here be discussed in so far, merely, as they are likely to present themselves to the general surgeon. For a fuller discussion of the topic the reader is referred to special works. Invasion of the labyrinth is characterized by continuous pain, felt deeply in the ear and usually of a dull character, and by total loss of bone conduction of the sound of the tuning fork placed over the mastoid process.

Mastoiditis.—The most frequent complication of middle-ear disease is inflammation of the mastoid process. The mucous membrane of the antrum and the air cells of the mastoid may be the seat of a catarrhal or purulent inflammation, or of a desquamative inflammation, with the formation of cholesteatomatous masses. The bone may be the seat of osteomyelitis or periostitis, followed by caries or necrosis. The signs and symptoms of mastoiditis vary a good deal, according to the more acute or chronic character of the process, according to the structures affected—whether mucous membrane, bone, periosteum—and according to the age of the patient.

Tenderness on pressure over the mastoid process is one of the most constant symptoms. Although such tenderness is quite common in acute inflammation of the middle ear, its continuance for days or weeks after the middle ear has been drained and the acute symptoms have subsided is strongly suggestive of mastoid disease. The persistence of free purulent discharge from the middle ear—after adequate drainage and careful local treatment in the absence of any evident lesion of the structures of the middle ear itself sufficient to account for persistent suppuration—renders involvement of the mastoid very probable. An irregular febrile movement, coming without apparent change in the condition of the middle ear, is of similar significance. Tenderness may be distinctly localized over some small area, and points to a suppuration limited to or more intense in that area. If such a tender area rapidly increases in size, it is strong evidence of a spreading process in the bone. *Localized or diffuse tenderness and swelling over the mastoid point to periostitis.* The swelling is often first noticed along the posterior surface of the mastoid or at the root of the mastoid; this latter is the commonest site for perforation of the

bone and the formation of an abscess. Some of the different points between mastoiditis and phlegmonous inflammation or abscess in the soft parts of this region have already been discussed in speaking of the diagnosis of these latter conditions.

The *pain* of mastoiditis varies greatly in intensity according as the process is more acute or chronic. It is very generally present, and in the more acute forms it may be severe, and of a boring or tearing character. It is referred to the mastoid itself, or to the depths of the ear, or to the entire region of the temporal bone. In chronic cases the pain may be absent. *Periostitis* causes the most marked symptoms of pain and tenderness. The pain may be continuous; it often varies much in intensity from hour to hour and from day to day. In the acute forms of the disease, and notably in children, there is fever. The fever is more marked, as a rule, in children than in adults. It is characterized by notable irregularity; may be intermittent, and quite commonly shows marked exacerbations and remissions from time to time without apparent cause. In chronic cases and among adults fever is frequently absent. Leucocytosis will be present or absent, according to the amount of septic absorption or the intensity of the infection.

If the suppurative process of the bone has extended to the periosteum and has involved the neighboring soft parts, an abscess, a cellulitis, a phlegmonous inflammation, or an involvement of the contents of the cranium will occur and give rise to definite signs and symptoms. Thus an abscess may be formed over the mastoid process itself; or perforation forward may take place and cause edema, redness, and the formation of an abscess which will present in the posterior wall of the external auditory canal; or perforation through the bone may take place in an upward direction, and cause purulent pachymeningitis—which may remain localized and only be discovered at the time of operation upon the mastoid, when it will be found that the entire thickness of the skull forming the upper and inner wall of the antrum is carious, and the removal of such bone will expose the infected dura—and sometimes an extradural abscess, or meningitis, or abscess of the cerebrum. If the infection involves the inner wall of the mastoid process, it is likely to extend to the lateral sinus and cause sinus phlebitis or infection of the cerebellum. (See, also, Pyemia, The Brain and its Membranes.) If the perforation extends downward, it may cause cellulitis or phlegmonous inflammation of the intermuscular planes of the neck. Infection of the interior of the skull may also occur by extension along the blood-vessels or fibrous connective-tissue bundles passing from the dura into the middle ear. Also, infection of the bony walls of the labyrinth and extension to the dura by continuity of structure; in this case further extension involves the cerebellum.

Tuberculosis of the Middle Ear.—Tuberculosis of the middle ear usually, but not always, occurs in the presence of advanced tuberculosis of the lungs. The diagnosis is to be made by the recognition of tubercle bacilli in the discharge from the ear. There may be entire absence of pain. The commonly

extensive involvement of the bone often causes facial paralysis and destruction of the labyrinth with total deafness. In general, the prognosis is unfavorable.

Pachymeningitis externa.—Pachymeningitis externa, alone, usually occurs by continuity of structure through carious bone, and often remains as a localized process, sometimes with the formation of an abscess between the dura and the bone. There may be no symptoms other than those referable to the diseased bone. In other cases there will be localized headache; sometimes slight symptoms of intracranial pressure, such as a slow pulse, nausea, vomiting; there may be dullness or impaired cerebration more or less marked. In children, invasion of the dura may be accompanied by a rigor and a febrile movement. Distinct localizing symptoms are almost never present.

Leptomeningitis.—Leptomeningitis follows infection of the internal surface of the dura and pia mater; the acute form, running a rapidly fatal course in a few days, or a subacute form, lasting several weeks, may result. Their symptoms have been sufficiently described in Diseases of the Brain and its Membranes.

For the signs and symptoms of **sinus thrombosis** and of **abscess of the brain following middle-ear diseases,** see, also, Diseases of the Brain and its Membranes.

Osteomyelitis of the Mastoid. Abscess in the Soft Parts.—In a certain number of cases of middle-ear disease infection of the mastoid is, as stated, followed by purulent osteomyelitis and periostitis, and the formation of an abscess of the soft parts. Such abscesses may break spontaneously and leave behind a sinus leading to carious or necrotic bone. The diagnosis of these conditions depends upon a history of disease of the ear, usually the presence of a discharge from the ear and a perforation of the tympanum, the existence of a sinus leading to rough or exposed bone, readily recognized by the introduction of a probe. The suppurative disease of the mastoid is exceedingly rare except as a secondary process to disease of the ear or to traumatism.

Primary Tuberculosis of the Mastoid Process.—Primary tuberculosis of the mastoid process may occur in children, and lead to the formation of abscesses, sinuses, and tuberculous caries, recognizable as tuberculosis by its chronic course and the signs already described under Tuberculosis of Bone.

CHAPTER XVIII

INJURIES AND DISEASES OF THE SALIVARY GLANDS

Injuries of the Parotid, Submaxillary, and Sublingual Glands.—From their protected positions injuries of the submaxillary and sublingual glands are infrequent, and have no special diagnostic interest. The parotid gland is more often injured by cuts, stabs, and the like, and its injuries are interesting from the fact that division and laceration of the *duct* of the gland is sometimes followed by salivary fistula. Incisions into and accidental wounds of the gland itself usually heal promptly. A slight discharge of saliva is sometimes observed in those wounds, which do not heal *per primam*, but is usually of no importance. A small, cystlike accumulation of saliva may occur between the wound edges, but fistula does not result.

Injuries of Steno's Duct.—Injuries of Steno's duct are of more interest. The direction of the duct is in a line from the base of the lobule of the ear running forward to the red border of the upper lip or a little higher, and deep wounds of the cheek which cross this line may injure the duct. The duct is of small size, and incised wounds involving it usually cut it completely in two. The diagnosis of a division of the duct can usually be made readily enough by direct inspection of the wound after the bleeding has been stopped. The ends of the duct can often be seen in the wound. In cases of doubt, the patient may be given something to chew which will excite the flow of saliva. Saliva will then appear in the wound. The diagnosis may be further confirmed by passing a small probe through the orifice of the duct in the mouth into the wound; in order to do this, the corner of the mouth is pulled forward, upward, and outward, when the orifice of the duct can be seen and the probe introduced. The orifice of the duct lies normally opposite the second molar tooth of the upper jaw.

Salivary Fistula.—When, as the result of an injury or of disease, there is an abnormal opening left, either on the skin or the mucous membrane of the cheek, through which saliva flows, the condition is known as *salivary fistula*. As a general rule, the fistulæ which open upon the mucous membrane of the mouth are of no consequence. Those which open upon the cutaneous surface of the cheek are sometimes annoying and troublesome. If these fistulæ communicate merely with the glandular tissue, or a small branch of the duct, they nearly always heal spontaneously in the course of weeks or months. If

they involve Steno's duct itself, they frequently do not. The diagnosis of the presence of the fistula is simple. A small opening exists in the skin of the cheek, through which saliva flows; the opening is usually in the line of the duct, but may be removed from it some distance in case injury to the duct has been followed by an abscess which has opened at a distance from the duct, and has left a fistulous tract behind. If it can be demonstrated that the peripheral portion of the duct is closed, or if the cutaneous orifice of the fistula and the mucous membrane of the mouth are adherent one to the other, or if there has been a considerable loss of substance in the duct itself, the fistula will be permanent, and will require a surgical operation for its relief.

Foreign Bodies in the Salivary Ducts.—Foreign bodies get into the duct of the submaxillary gland more often than into Steno's duct. Such foreign bodies may be hairs or bristles, pointed bits of wood, fish bones, minute fruit seeds, a small bird shot, and the like. If the foreign body is small, it may produce no symptoms at all, or, if larger, it may set up irritation or inflammation of the duct and of the gland, with the production of an abscess; sometimes, of a salivary fistula; or the foreign body may become the nucleus of a salivary calculus, and by damming back the saliva in the duct may cause quite serious symptoms. At the moment of the introduction of the foreign body the patient may experience severe pain in the duct itself and in the salivary gland. If the body is large enough to interfere with the flow of the saliva, it may cause painful swelling and inflammation of the gland.

The *diagnosis* is sometimes easy and sometimes quite difficult. The foreign body may be seen protruding from the orifice of the duct on inspection; or it may be felt by palpation with the finger, along the line of the duct in the mouth. Occasionally it may be possible to introduce a fine probe into the duct and feel the foreign body. If the foreign body happens to be metallic, as, for example, a bird shot, or if, as is sometimes the case, it has remained for some time in the duct, and become coated with lime salts, it might be detected by means of the X-rays. In many instances the surgeon will not see the patient until the foreign body has been present for some time. There will then usually be a history of a sudden sharp pain in the salivary gland and in the duct, followed by continuous or intermittent swelling of the gland and pain. Upon inspection and palpation in the mouth, the orifice of the duct may be red and swollen; the duct may be enlarged, hard, and tender; there may be a purulent discharge from its orifice. The salivary gland will usually be enlarged and swollen.

Formation of Calculi in the Salivary Ducts.—The formation of calculi in the salivary ducts is a comparatively rare disease; such calculi occur most often in Wharton's duct—the duct of the submaxillary gland. They may be single or multiple. The *symptoms* produced by salivary calculi depend upon the mechanical stoppage of the duct, due to the presence of the calculus and to infection. In some cases the calculus may exist in the duct for a long time without producing any symptoms. In other cases the symptoms are very

marked indeed. They consist of sharp attacks of pain, coming on suddenly, excited by the act of eating, or even by the sight of food; the pain is quite severe, and is felt in the floor of the mouth and in the submaxillary region. The pain is followed by swelling of the submaxillary gland and of the duct. The pain and swelling continue, sometimes for hours, to be followed by the discharge of a considerable quantity of saliva into the mouth and temporary relief of the symptoms. In other cases the characteristic attacks are wanting. There is a chronic or intermittent discharge of pus from the duct of the gland, and a chronic inflammation and enlargement of the gland itself. The condition may eventuate in a phlegmonous inflammation of the salivary gland with the production of an abscess in the submaxillary region of the neck or in the floor of the mouth.

The *diagnosis* of salivary calculus in Wharton's duct is sometimes very easy and sometimes difficult. If the calculus can be felt as a hard body by palpation in the floor of the mouth, or by bimanual palpation, it is not likely to be mistaken for anything else. In case the stone lies immediately beneath the mucous membrane not far from the orifice of the duct, it may sometimes be seen as a whitish body shimmering through the thinned mucous membrane. The stone may sometimes be detected by introducing a fine probe into the duct, or if the probe cannot be inserted, and a hard mass is felt rather deeply placed, a needle may be introduced into the tissues, and by the grating sensation imparted when it strikes the stone the diagnosis will be made clear. The diagnosis has also been made in several instances by means of the X-rays. In case marked inflammatory symptoms are present, the diagnosis, in the absence of a characteristic history, is apt to be missed. The swollen gland may be mistaken for almost any sort of an inflammatory or even malignant growth. In one case which I saw of salivary calculi, the patient had already been operated upon, and two calculi removed from Wharton's duct. The disease had recurred, and the patient was suffering from frequently repeated attacks of pain. Three calculi were present, each about the size of a dried pea: two of them were palpable readily enough in the floor of the mouth; the third lay deeply embedded in the substance of the gland. The patient desired to have his submaxillary gland removed. This I did with, of course, a cure of the pain from which he had suffered.

Inflammations of the Salivary Glands.—Inflammations of the salivary glands are caused, in nearly all cases, by the invasion of the orifices of the glandular ducts in the mouth by pathogenic microbes, and the subsequent extension of bacterial infection along the ducts of the glandular tissue. The pyogenic cocci, the pneumococcus, the bacillus typhosus are more often present than other forms. Epidemic parotitis, or mumps, is probably no exception to this manner of infection, since the swelling of the parotid is nearly always preceded by a more or less marked stomatitis. A dirty mouth, stomatitis of all kinds, whether due to bad teeth, or neglect of the mouth, or to mercurial or lead poisoning, or scurvy, are favorable to infection. Acute infectious diseases—scarlet fever,

typhoid, diphtheria, measles, small-pox, typhus fever—are not uncommonly complicated by inflammation of the parotid. Further, surgical operations, notably abdominal and pelvic operations, whether clean or infected; pyemia; and other septic diseases, may all be followed by parotitis.

Epidemic Parotitis (Mumps).—An infectious, contagious disease, probably caused by a specific microbe, occurs sometimes in epidemics, and is characterized by swelling and inflammation of one or both parotid glands. Sometimes by inflammation of the other salivary glands, and by more or less marked constitutional symptoms. Inflammations of the mammary gland and ovary occur as complications in females and of the testis in males. The inflammation usually ends in resolution and *restitutio ad integrum*; very rarely in suppuration. Children between the ages of two to sixteen years are most commonly affected, less often adults. The period of incubation is about two weeks; there are usually prodromal symptoms lasting from two to ten days. They are stomatitis, disturbances of digestion, sometimes diarrhea, loss of appetite and nausea, malaise, and slight fever. Suddenly one or both parotid glands become painful and rapidly swollen and tender; there is a decided rise of temperature. The swelling of the parotid causes a marked prominence and characteristic deformity. There is pain on swallowing and speaking, the motion of the jaw is limited. In uncomplicated cases the fever lasts about a week, and subsides by crisis. The swelling of the parotid slowly subsides and is gone at the end of ten days; sometimes not for two or three weeks. Successive involvement of other glands causes a prolongation of the constitutional symptoms. Involvement of the ovary is accompanied by pain and tenderness, sometimes by vulvo-vaginitis and a muco-purulent discharge. Involvement of the testis is attended by marked swelling of the testis itself, not of the epididymis or vas. In one third of the cases of testicular involvement, atrophy of the organ, complete or partial, follows.

Inflammations of the Parotid Gland.—The acute inflammations of the parotid gland, complicating sepsis, acute infectious fevers, and surgical operations, are of more interest because they not infrequently end in suppuration. They appear during the later weeks of typhoid, scarlet fever, etc.; in the presence of an infected fracture; after an operation for pus tubes, an appendicitis, etc.; or in the presence of an ordinary stomatitis, or of a mercurial or lead stomatitis, or of scurvy.

The inflammation of the parotid usually comes on quite suddenly, and, if the infection is of a severe type, is often accompanied by a chill, a marked rise of temperature, prostration, a rapid pulse, leucocytosis, and other septic symptoms; or if the infection is of a mild type, pronounced general symptoms may be absent. The swelling of the gland is first noticeable at the angle of the jaw in front of the ear. The lobule of the ear is raised and prominent; the swelling gradually involves the entire parotid region. If the process is to end in resolution, the swelling, pain, etc., and the constitutional symptoms, gradually subside after a few days. If, as is quite common, suppuration

occurs, the local and general symptoms become more marked. The overlying skin becomes swollen, edematous, and red. Fluctuation is hard to make out because much of the gland is covered by dense fascial structures. The abscess, if not incised, may break into the external auditory canal, or upon the cheek, into the pharynx, or burrow down the intermuscular planes of the neck. If the general and local symptoms continue to increase after four or five days, the surgeon is justified in searching for pus, always bearing in mind the relations of the facial nerve to the gland. Death may occur from septic poisoning, from venous thrombosis and pyemia, or meningitis, or from the spread of the infection downward into the mediastinum.

Acute Suppurative Inflammation of the Submaxillary Gland.—Acute suppurative inflammation of the submaxillary gland may arise from any of the causes already described as causing inflammation of the parotid, but its infection is less common, and, generally speaking, when it does occur, it is less dangerous than is the case with the parotid. Suppuration in the *submaxillary triangle* is, however, common as the result of purulent infection of the loose connective tissue of that region; following stomatitis; infection through carious teeth; periostitis and osteomyelitis of the lower jaw; suppuration of the submaxillary lymph nodes; and, less commonly, from infection of the submaxillary gland itself. The diagnosis does not materially differ from that of the condition about to be described which has received a special name—that of the man who first described it—Ludwig, of Württemberg.

Angina Ludovici.—Angina Ludovici is a more or less violent, purulent, sometimes gangrenous, inflammation of tissues occupying the submaxillary triangle of the neck. Characterized by severe septic symptoms; the formation of a hard, tense, brawny swelling in the submaxillary region; great pain; difficulty in speaking and swallowing; sometimes by cyanosis and dyspnea from pressure on the larynx or from swelling and edema of the throat. The local signs and symptoms of an acute abscess or of a phlegmonous inflammation are absolutely typical. If unrelieved by very early incision, the whole side of the neck becomes a deep mahogany red, as hard as a board; the constitutional symptoms threatening, and the local symptoms of interference with respiration alarming. The necrotic and suppurative process tends to burrow down the neck and into the mediastinum. In the necrotic forms the streptococcus is usually present; in the localized abscesses, staphylococci. It is to be understood that in many cases the infection is less intense, and the local and general symptoms less stormy and severe, than those just outlined. In any case the diagnosis of a localized suppurative process is entirely plain.

Chronic Interstitial Inflammation of the Submaxillary Gland.—Chronic interstitial inflammation of the submaxillary gland, with occasional exacerbations of acute inflammation, leading, in time, to the production of a considerable tumor in the submaxillary region—quite hard, often painless, usually adherent to the surrounding tissues—has been observed in a few cases. The condition is interesting from a diagnostic point of view because it is apt to be mistaken for a

gumma or a malignant new growth. On section, the lobulated glandular character is preserved. There is an increased production of interstitial connective tissue, abundant round-celled infiltration, the formation here and there of small areas of granulation tissue, and microscopic abscesses in some cases.

von Mikulicz Disease.—A simultaneous symmetrical enlargement of the salivary glands and of tear glands, without inflammatory complications, was first described by von Mikulicz. The pathology of the condition is obscure. The diagnosis is made by inspection. The enlargement of the salivary and tear glands causes visible swellings. The disease is chronic, and does not end in suppuration.

Syphilis and Tuberculous Inflammation of the Salivary Glands.—Syphilitic and tuberculous inflammation of the salivary glands occasionally occur. In the secondary stage of syphilis an acute inflammation of the parotid, not unlike mumps, has been observed in a very few cases. The diagnosis is to be made by the presence of other syphilitic manifestations. Gummata also have been observed in the parotid as slowly growing, nodular, painless tumors, which may later undergo softening and ulceration of a characteristic kind. In the absence of softening, and with no other lesions present, a history of syphilis being denied, these gummata would probably be mistaken for a new growth. A tertiary syphilitic sclerosis of the parotid with induration of the glandular tissue, but without ulceration, occasionally occurs as a late lesion of syphilis. I have recently had such a case under my care.

Tuberculosis.—Primary tuberculosis of the parotid gland has been observed in a few cases as a diffuse tubercular infiltration of a considerable portion of the gland, or, less commonly, as a circumscribed tuberculous focus in the substance of the gland, resulting in a cold abscess. In most of the cases the disease has not been associated with other tuberculous lesions. The symptoms consist of a chronic, diffuse, or circumscribed enlargement of the gland, usually not tender, and covered by normal or, later, by reddened and edematous skin. Neuralgic pain is sometimes present. The disease is so rare that a diagnosis is likely to be made only after operation and microscopic examination of the diseased tissues. The circumscribed forms are only to be differentiated from a tuberculous lymph node by the pathologist.

Cystic Dilatation of the Salivary Ducts.—Cystic dilatation of the salivary ducts, as the result of retention of the secretion of the gland, due to closure of the mouth of the duct from any cause—inflammation, salivary calculus, a foreign body, or from no assignable cause—is usually easy to recognize. The characteristic signs and symptoms of the most common form of the condition have been described under Ranula. They occur less commonly in Steno's and Wharton's ducts, and are recognizable as painless, insensitive, spindle-shaped, elastic tumors in the line of the duct. If they lie immediately beneath the mucous membrane they will be translucent. Such cysts of Steno's duct lie close to the skin of the cheek, and, if such is the case, *the introduction of an aspirating needle into the cyst through the skin is unwise, since a salivary*

fistula might thus be created. Exploration through the mucous membrane can, of course, do no harm. The contents of these cysts is clear saliva which may have undergone such changes as not to respond to tests for ptyalin, etc. If the duct of the gland is not entirely closed, it may be possible to express some of the contents through the orifice of the duct. Cysts of the Blandin-Nuhn glands present as translucent, thin-walled vesicles, usually of small size, at, or just beneath, the point of the tongue.

Cysts of the Salivary Glands.—Cysts of the salivary glands themselves are rather rare. Unless the cyst has attained a considerable size the diagnosis is not easy. They may attain the size of a blue plum or of a hen's egg; form rounded, elastic, fluctuating swellings. They contain clear saliva, and are most of them unilocular. The diagnosis must usually be made by puncture with a hypodermic needle.

Tumors of the Salivary Glands.—The same types of tumors occur in all the salivary glands. They are much more common in the parotid than in the submaxillary gland. The connective-tissue tumors are *angioma*, very rare; *lymphangioma*, also very rare. I operated on one case of lymphangioma of the parotid in a girl of ten. The tumor was the size of a hen's egg, covered with normal skin, soft, and compressible, but a certain tension was given to it by the capsule of the gland. It had grown slowly and produced no symptoms other than deformity. The tumor was removed, not easily, and was found to consist of a trabeculated connective tissue containing large spaces filled with clear fluid. Microscopic examination showed that the tumor was a lymphangioma. *Lipoma.*—A few cases have been observed, either as distinctly encapsulated tumors or intimately connected with the glandular substance. *Fibroma.*—Hard or firm fibroma is rarely observed as a slowly growing benign tumor of the parotid. *Sarcoma.*—The various forms of sarcoma occur in parotid. *Fibro-sarcoma* and *spindle-celled sarcoma* form firm, rounded tumors, which remain encapsulated for a long time, and remain fairly movable and are capable of enucleation (see Fig. 182). The more malignant types, which occur also in the submaxillary gland, are apt to grow rapidly, to speedily infil-

FIG. 182.—SARCOMA OF THE PAROTID GLAND.
(Collection of Dr. Charles McBurney.)

trate the entire glandular structure, to invade the surrounding structures, to involve the skin, the mucous membrane, to ulcerate, bleed, etc. They sometimes grow so rapidly that they may be mistaken for inflammatory processes. The most malignant of all is *melano-sarcoma.*

FIG. 183.—MIXED TUMOR OF THE PAROTID GLAND. (Collection of Dr. Charles McBurney.)

FIG. 184.—MIXED TUMOR OF THE PAROTID GLAND. (Collection of Dr. Charles McBurney.)

MIXED TUMORS OF THE SALIVARY GLANDS.—The most frequent and interesting tumors of the parotid are the so-called mixed tumors. They are much less frequent in the submaxillary gland. They are generally tumors of rather slow growth, and may exist for many years before they attain a large size. They are also well encapsulated unless they undergo malignant degeneration. They form, when small, nodular, intraglandular, or extraglandular masses of smooth or uneven surface, usually somewhat movable. Their consistence is very variable, since they are usually made up of a variety of hard and soft tissues. Hard portions alternate with softer or cystlike areas. These tumors may contain many kinds of tissue; combinations of enchondroma, fibroma, myxoma, adenoma, sarcoma, carcinoma, endothelioma, and striped muscle fiber, and bony, calcareous, and cystic areas may all be found in various combinations. A large proportion of these tumors are observed between the ages of fifteen and thirty years. A few are congenital, and extreme old age is not exempt. They very often grow slowly for many years, and then suddenly take on a rapid and destructive character showing the qualities of sarcoma or carcinoma, as the case may be. Such malignant changes are said to take place in about ten per cent of all cases. If seen during their earlier stages, they should be extirpated as soon as discovered. When mixed tumors of the parotid have attained a certain size, they may give rise to pressure symptoms; pain,

by pressure on the branches of the fifth nerve; and facial paralysis from stretching and pressure on the facial, usually in its lower part, thus causing drooping of the mouth, etc., on one side.

The *diagnosis* is usually not difficult. The tumor forms a distinct nodular swelling, and produces a deformity which depends upon what part of the gland it occupies and the direction in which it grows. In the posterior part of the gland the tumor grows up beneath the ear, elevating the lobule, or behind the jaw toward the pharynx; in the front part of the gland the tumor produces a swelling on the cheek. In the submaxillary region the tumor produces a swelling in the neck beneath the jaw, but seldom grows toward the floor of the mouth. If the tumor is composed largely of cartilage, it will be very hard and of uneven surface. Very commonly such cartilaginous tumors contain areas of myxomatous degeneration which give a sensation resembling fluctuation.

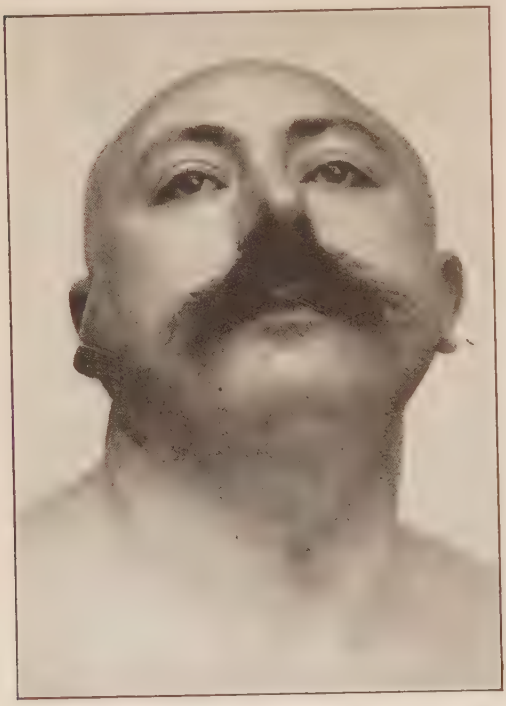


Fig. 185.—Mixed Tumor of the Parotid Gland. (Author's collection.)

A diagnosis between this soft tissue and true cyst formation can only be made with an aspirating needle. If fibroma predominates in the growth, the surface will be smooth, and consistence firm. As long as the tumor remains benign it will possess a capsule and be distinctly movable and sharply defined from the surrounding parts. The tumor is covered by normal non-adherent skin, is not tender, and only exceptionally painful. A suddenly acquired rapidity of growth is almost a certain sign of malignant activity. If not soon removed the capsule will be lost and the tumor acquire the malignant characters already described. While mixed tumors are of slow growth, they produce so few symptoms, as a rule, other than deformity that their possessors are apt to postpone their removal. They may thus attain in the course of years a very large size. (See illustrations.)

Tuberculous Lymph Nodes in the Parotid.—A solitary tuberculous gland sometimes occurs in front of the ear, and might be mistaken for a tumor. After such a gland has existed for some time it is very apt to become adherent to the surrounding tissues, to break down and become adherent to the skin, showing fluctuation.

Adenoma.—Purely adenomatous tumors of the salivary glands have occasionally been observed. They form encapsulated tumors, lobulated, of firm or soft consistence, usually of slow growth. Clinically they are not to be differentiated from mixed tumors.

Carcinoma.—Carcinoma occurs both in the parotid and submaxillary glands, oftener in the former. It is difficult to say whether some of the epitheliomata of the floor of the mouth originate in the sublingual gland or not. The carcinomata of the parotid may be of the scirrhous variety, or rapidly growing cellular forms.

Fig. 186.—Sarcoma of the Parotid Gland. Round- and spindle-celled type. Patient remained well five years after operation. (Author's collection.)

Fig. 187.—Photograph of Patient Shown in Fig. 186 taken soon after the Operation, Showing Scar and Facial Paralysis.

Scirrhus.—Scirrhus occurs in old people, oftener in men than women. Its progress is relatively slow, and causes atrophic changes rather than the production of a considerable tumor. The glandular tissue becomes indurated, and the contraction of the abundant fibrous stroma of the tumor causes puckering and indentation of the skin over the growth. Secondary involvement of the lymph nodes in the neck is usually late, and the secondary tumors rarely attain a large size. The involvement of the facial nerve causes paralysis of the face, frequently only partial. Pain is rarely marked. The skin may be extensively

infiltrated, and the infiltration may extend well down on the neck and limit the motions of the head, causing a slight degree of wry-neck.

Soft Cellular Form of Carcinoma.—The soft cellular form of carcinoma presents quite a different picture. Microscopically, these tumors resemble an acinous gland, with a poorly developed stroma. They are rapidly growing forms, soft, soon invade the skin, ulcerate, bleed, often dangerously, undergo putrefactive changes, etc. They early become painful, often terribly painful, cause facial paralysis, often deafness, grow inward into the pharynx, downward into the neck, cause difficulty in swallowing, speaking, and breathing. Soon infect the lymph nodes, forming rapidly growing secondary tumors and metastases, and have all the characters of the most malignant growths. The duration of life may be as short as six months after the discovery of the tumor. Death occurs from repeated hemorrhages, sepsis, erysipelas, exhaustion, asphyxia, etc.

The *diagnosis of carcinoma of the parotid or submaxillary glands* presents not the slightest difficulty after the tumors are far advanced. In their early stages, however, when treatment is still possible, they may readily be mistaken for an acute or subacute inflammatory process—syphilis, tuberculosis of the soft parts, or even a purulent infection. They grow so fast, so early become painful, exhibit redness and tenderness of the skin, etc., that an exploratory incision and the removal of a small portion of the tumor for immediate microscopic examination may be necessary, or at least desirable. The early occurrence of facial paralysis should lead to a suspicion of malignant disease. One of the difficulties is that these rapidly growing cancers may occur in quite young people.

CHAPTER XIX

THE NECK

CONGENITAL DEFECTS OF THE NECK

Congenital Fistulæ of the Neck.—Congenital fistulæ of the neck arise from (1) the second branchial cleft, (2) from the thyreo-glossal duct.

1. Fistulæ Arising from Imperfect Closure of the Second Branchial Cleft.—Fistulæ arising from imperfect closure of the second branchial cleft may be complete or incomplete. The incomplete fistulæ may have: (*a*) An external opening, but fail to communicate with the pharynx—*incomplete external fistula.* (*b*) An opening into the pharynx, but no opening in the skin of the neck—*incomplete internal fistula.* The external opening of these fistulæ lies in the skin of the neck, between the anterior border of the sterno-mastoid muscle and the median line of the front of the neck, and between the greater cornu of the hyoid bone and the sterno-clavicular joint of the same side. The external opening is usually very small, often so small as only to admit a filiform guide or a bristle. The inner opening lies in the neighborhood of the tonsil, in the lateral wall of the pharynx, or near the pillars of the fauces. In passing from the skin to the pharynx the path of the fistula is through the skin and superficial fascia, along the deep fascia covering the sterno-hyoid and sterno-thyroid muscles, between the external and internal carotid arteries, to the neighborhood of the greater cornu of the hyoid bone, and thence to the pharyngeal wall. The digastric muscle is superficial to the path of the fistula, the hypoglossal and glosso-pharyngeal nerves lie beneath it. That portion of the fistulous tract derived from the hypoblast is lined with cylindrical epithelium. That portion derived from the epiblast is lined with flat pavement epithelium. This arrangement is the rule; exceptions, however, may occur. The portion derived from the hypoblast is said always to contain a layer of lymphoid cells in its wall. These fistulæ may be complete or incomplete at first. The incomplete fistulæ may subsequently become complete by the formation of a cystic enlargement, which finally perforates inwardly or outwardly.

The *diagnosis* of these fistulæ, if present at birth, is not difficult. If they form secondarily, they may be mistaken for sinuses of other origins. The discharge from the fistula consists of clear stringy mucus, or of a thinner, milky, or turbid fluid resembling thin pus. The amount of discharge varies greatly. It may be very slight, scarcely noticeable, only a drop now and then, or so pro-

fuse as to constitute a serious annoyance and to cause irritation of the skin of the neck. It is sometimes possible to feel the wall of the tract as a fibrous cord in the neck. It is not usually possible to pass any instrument throughout the entire length of the fistulous canal. In the complete fistulæ it is sometimes possible to inject fluid through the external opening into the pharynx; the passage of the fluid into the pharynx may be recognized by the patient by its taste, or by the surgeon by its color (strychnin, quinin, milk, or methylene-blue solution). If the internal opening is large, small portions of food may pass from the pharynx outwardly to the skin. If the fistula has no external opening, or if that opening becomes closed, the accumulation of food, etc., in the tract may lead to inflammatory symptoms or even to the symptoms of a diverticulum of the pharynx, regurgitation of the food into the pharynx, or difficulty in swallowing. The character of the epithelium lining the tract is an important aid in the diagnosis; cylindrical epithelium in the part derived from the pharynx (hypoblast—entoderm); pavement epithelium in the part derived from the cutaneous layer (epiblast—ectoderm).

2. Fistula Arising from the Thyreo-glossal Duct.—The thyreo-glossal or thyreo-lingual duct in early fetal life forms a canal lined with ciliated epithelium running from the foramen cecum at the base of the tongue, downward and forward in the middle line, to the isthmus of the thyroid gland. This canal, from the foramen cecum to the hyoid bone, is known as the *lingual duct.* From the hyoid bone to the isthmus of the thyroid as the *thyroid duct.* While, normally, the entire canal is obliterated in early fetal life, in certain instances it may remain patent, throughout, or in part. A fistula only results when a communication with the skin in the middle line of the neck is established. These fistulæ are usually not congenital. The external opening, when formed, is in the middle line of the neck between the hyoid bone and the sternum. The opening is usually minute, and it is only possible to introduce a probe as far as the hyoid bone. The deeper portion of the fistulous tract is lined by ciliated cylindrical epithelium; that part nearest the foramen cecum of the tongue with flat epithelium. It is to be remembered that suppuration may change or destroy this epithelial lining.

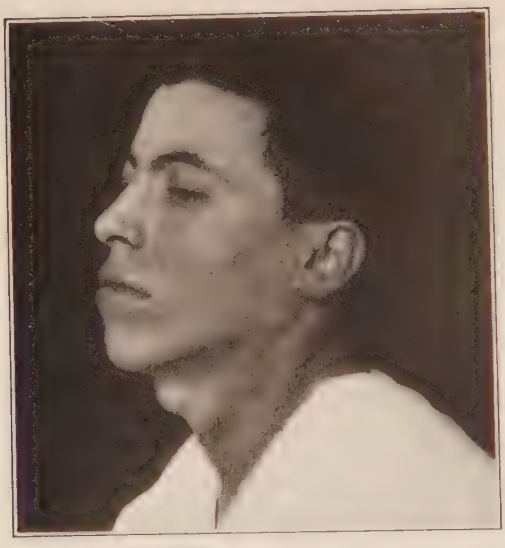


Fig. 188.—Cyst Developed in a Persistent Thyreoglossal Duct. (Author's case.)

Along the sterno-mastoid muscle there occur small congenital outgrowths,

sometimes of skin, sometimes containing, also, plaques of cartilage, which are believed to have a morphological relation with the branchial arches and clefts. (See Supernumerary Auricles.)

Cervical Ribs.—Cervical ribs occur not very rarely. They are always connected with the seventh cervical vertebra, usually by a regular joint. They are unilateral or bilateral. The development of the rib varies in different cases. It may scarcely project beyond the transverse process of the vertebra. It may extend farther forward and end free. It may unite with the first rib proper by fibrous or bony union, or finally with the sternum. The subclavian artery passes over the cervical rib, if it is long; or in front of it, if short; never below it. The brachial plexus lies always below. The existence of such a rib is of interest because it may cause pressure symptoms, either of a circulatory or nervous character.

The *symptoms* usually come on between the fifteenth and twentieth years of life. The circulatory disturbances are caused by the pressure of the rib against the subclavian artery. In some cases they are very slight or absent; there may be noticed only a slightly less perfect development in the muscles of the arm, or the arm may be distinctly less well nourished than its fellow; the fingers may be pale and cold; actual gangrene of the ends of the fingers has been observed in one case. The compression of the artery may be sufficient to cause thrombosis and obliteration of the vessel, but the process is slow, and ample time is permitted for the establishment of a collateral circulation. The symptoms due to compression of the brachial plexus of nerves consist chiefly of sensory disturbances, neuralgic pains—either localized or general—paresthesiæ, numbness, coldness, formication. Motor symptoms are absent, except that diminished electrical excitability of the muscles and of the nerves has been observed. The *diagnosis* is not usually difficult. Instead of the normal flatness or concavity in the supraclavicular region, a pulsating swelling covered by normal skin is noted. Firm pressure on this swelling causes obliteration of the radial pulse, slight pressure may produce a thrill. Behind and below can be felt the rib, hard, as broad as a finger, attached or movable in front. Such a rib may be mistaken for an exostosis of the first rib. Such exostoses usually cause compression of the vein rather than the artery and edema of the arm. A positive diagnosis is easily established in a doubtful case by an X-ray picture.

Wry-neck (*Torticollis—Caput obstipum*).—The term wry-neck is used to designate a variety of conditions which have this in common, that they are attended by shortening or spasm of some of the muscles on one side of the neck, especially of the sterno-mastoid muscle, and are characterized by a peculiar, easily recognizable deformity, such that, in typical cases, the chin is raised and turned toward the sound side; the ear of the affected side is depressed and approached to the shoulder. (See Fig. 189.) The occiput is approximated to the shoulder of the affected side. The deformity varies in degree in different cases. An attempt to straighten the position of the head is met by strong resistance on the part of the sterno-mastoid and sometimes of

other muscles. As a chronic or permanent condition the *causation* and *pathology* of torticollis is somewhat obscure. It is believed by some observers—denied by others—that the condition is congenital in the sense that the shortening of the muscles occurs during intra-uterine life. Some observers believe that the condition is caused by injury to the sterno-mastoid muscle during labor, sometimes by the use of obstetric forceps, or during the delivery of the after-coming head. This accident is supposed to cause a rupture or a hematoma in the muscle, resulting in the formation of scar tissue, in some instances in a progressive chronic interstitial myositis with destruction of the muscular fibers and their replacement by fibrous tissue. It has been assumed by some surgeons that a hematogenous infection of the muscle injured during labor takes place through the alimentary canal, but this theory of causation remains to be proven.

Fig. 189.—Wry-Neck of Congenital Origin in a Little Girl. Congenital elevation of the scapula. (Collection of Dr. Charles McBurney.)

The deformity is generally noticed after the child is a few months old; upon examination, the peculiar position of the head is evident; palpation of the sterno-mastoid muscle upon the affected side shows that it is hard, inelastic, and stretches as a tense, firm band, straight downward from the mastoid process to its insertion in the clavicle and sternum. The hardness and rigidity of the muscle is often most marked near its lower end. If the child is allowed to grow up with this condition unrelieved, secondary changes take place. A lateral curvature of the spine in the cervical region is gradually developed with its concavity toward the affected side. The intervertebral disks, and the bodies of the cervical vertebræ themselves, are thinner upon the affected side, so that

Fig. 190.—Congenital Wry-Neck in a Boy. (Collection of Dr. Charles McBurney.)

the deformity of the spine tends to become permanent. This scoliosis may continue in a single curve into the dorsal region. Usually a compensatory scoliosis in the opposite direction takes place in the upper dorsal region; this dorsal compensatory scoliosis is usually not developed until the disease has existed for some time. The two sides of the face develop unequally; upon the affected side the face is broader and lower than upon the other. The skin upon the affected side of the neck is often thrown into folds. All the structures of the neck—the muscles, the blood-vessels, the nerves—are shorter upon the affected side.

Other Forms of Wry-neck.—In addition to this form of torticollis, which is either congenital or occurs soon after birth, a number of other acute or chronic conditions give rise to wry-neck. Among them may be mentioned cicatricial contraction of the side of the neck due to burns; cicatricial contraction of the skin, or of the muscles and fascia, such as may be produced by traumatisms with loss of substance, and by phlegmonous processes in the neck. In acute inflammatory conditions of the neck—abscesses, phlegmons, etc.—the sterno-mastoid upon the affected side is relaxed for the relief of tension; that upon the sound side contracted. As the result of tubercular or syphilitic inflammation of the sterno-mastoid muscle, or of the growth of tumors, sarcoma, or carcinoma in the muscle, the sterno-mastoid may lose its elasticity, become rigid and shortened. Further, as the result of dislocations of the cervical vertebræ, of tuberculosis of the bodies of the vertebræ, deformities, more or less closely resembling typical wry-neck, are not uncommon. (See Dislocations and Tuberculosis of the Cervical Vertebræ.)

Further, as the result of local irritations, notably of pediculosis capitis, well-marked spasm of the sterno-mastoid muscle may occur, which promptly or slowly disappears when the irritation is removed. As the result of exposure to cold and wet, or from other causes, the so-called *muscular rheumatism* may affect the sterno-mastoid muscle. The attack usually comes on quite suddenly, often without warning. The patient feels a more or less intense pain in the side of the neck, and the head involuntarily assumes a wry-neck position. The muscle is more or less tender, and an attempt to straighten the head is painful. The condition may last for hours or days, and in very rare cases may become chronic. As a complication of acute infectious disease—scarlet fever, measles, typhoid, etc.—an inflammation of the sterno-mastoid muscle may occur, and in some instances may lead to permanent replacement of the muscular fibers by fibrous tissue. Of all the muscles of the neck the sterno-mastoid is more often than any other the seat of *gummata* or of a diffuse *syphilitic interstitial myositis* with replacement of the muscular fibers by fibrous tissue.

Spasmodic Torticollis. Spasmodic Wry-neck.—As the result of obscure changes in the central origins of the spinal-accessory and the three upper cervical nerves, sometimes from changes in the nerves themselves, a chronic condition of nervous irritation ensues, characterized by tonic or clonic spasms,

or both, of certain muscles of the neck. The sterno-mastoid is most often affected, and other muscles frequently take part—trapezius, splenius, obliquus capitis inferior, complexus—sometimes on both sides of the neck. When the spasm is tonic, and affects chiefly the sterno-mastoid, the position of the head is that of ordinary wry-neck; by the implication of other muscles the deformity is varied in several ways. The clonic spasms cause rotary, or nodding, or oblique movements of the head, elevation of the shoulder, and other movements, such as throwing back of the head and wrinkling of the forehead when both trapezii are involved, etc. The disease is more common in women than in men, seldom occurs before the age of thirty, and is sometimes of a traumatic or of a distinctly neurotic origin. The spasms are not attended by pain, but are extremely distressing to the patient because of inability to keep still, and even, sometimes, to do any work. Mental depression is common. The affected muscles usually become more or less enlarged from continued use.

INJURIES OF THE NECK

Injuries of the neck are subcutaneous injuries or open wounds. The most important structures injured are the blood-vessels, nerves, the air passages, the esophagus, the hyoid bone and the thoracic duct.

Subcutaneous Injuries of the Neck

Subcutaneous injuries of the neck occur as the result of blows and falls; further, from crushing injuries—as when the wheel of a vehicle passes over the neck, or when the neck is caught by a piece of moving machinery, or by a moving elevator; as the result of hanging, garroting, and choking. Such injuries are more or less serious or fatal according to the amount and character of the violence, the duration of its application, and the structures injured. A fatal asphyxia may follow a blow upon the larynx which causes no gross injury, by spasm or paralysis of the muscles of the glottis, or, on the other hand, by severe violence the trachea may be completely torn across.

When an individual is choked to death by another, the prints of the assailant's fingers can usually be distinguished as scratches, ecchymoses, and livid marks on the skin. When garroted by a cord, a livid groove can be seen entirely encircling the neck. Hanging, on the other hand, usually does not leave a complete circle around the neck, showing the point of application of the rope, at least in cases of suicide. In cases of judicial hanging the violence is extreme, and the mark of the rope may completely encircle the neck. The presence of ecchymosis in and beneath the skin in the vicinity of such marks indicates that the constriction took place before death. Its absence, if a hard cord or rope was used, indicates that death was due to other causes. In judicial hangings the lesions produced are often severe, and include rupture of muscles, vessels, nerves, and often dislocation of the upper cervical vertebræ, frequently

of the atlas and axis, with rupture or crushing of the spinal cord. In suicidal hangings, and murders by tying a cord or other ligature about the neck, death occurs from asphyxia by closure of the upper orifice of the larynx or of the trachea by direct compression. The hyoid bone and larynx may be fractured. In case the strangling is done with a band of soft cloth, such as a silk handkerchief, no mark whatever may be left upon the skin. Sudden constriction of the neck may cause rupture of the inner and middle coats of the carotids, followed later, if the patient survives the immediate effects of the injury, by thrombosis or aneurism. The immediate symptoms of the subcutaneous injuries of the neck involving injury of or pressure upon the windpipe are dyspnea, more or less severe, or asphyxia. Subcutaneous hemorrhage from rupture of large vessels may also, by pressure, cause asphyxia.

Fracture of the Hyoid Bone.—Fracture of the hyoid bone occurs as the result of hanging—judicial, homicidal, or suicidal; from grasping the throat in fighting, or strangling; from a blow; in rare instances, from muscular action. The fracture takes place through the body or greater cornu. The signs of fracture—mobility and crepitus—can usually be made out through the skin or with a finger in the mouth. The end of a fragment frequently perforates the mucous membrane of the pharynx, and profuse bleeding is not uncommon; a considerable hematoma may form in the neck. Subjectively, there is local pain and tenderness. The most marked symptoms are due to interference with swallowing and respiration; any attempt to swallow, or even to move the tongue or jaw, is attended by intense pain, and often by a paroxysm of choking and coughing; so that these patients have sometimes to be fed through a catheter or esophageal tube. Speaking is also interfered with, and is painful; there may be hoarseness or aphonia. The dyspnea is often marked, and may even require tracheotomy. Dislocation of the hyoid bone has been observed.

Fracture of the Larynx.—The fractures of the larynx occur through the thyroid and cricoid cartilages, very rarely through the arytenoid cartilages. The fractures are more common in men than in women, and among the middle-aged and elderly rather than the young. They result chiefly from violence exerted from side to side, tending to crush the cartilages of the larynx laterally, or violence directed from before backward, crushing the cartilages against the anterior surface of the vertebral column. The fractures are caused by blows, falls, hanging, strangling, run-over injuries, and gunshot wounds. When the fractures are produced by lateral compression of the larynx—as when the larynx is grasped between the fingers in the effort to choke the individual—the fracture of the thyroid occurs, usually near its anterior border and in a vertical direction; the ring of the cricoid is commonly broken at the same time, sometimes bilaterally, sometimes near the middle line in front. As the result of extreme degrees of violence and of gunshot wounds, the cartilages of the larynx may be more or less disintegrated and crushed to a pulp.

The *signs of fracture* are: Deformity, which is usually rapidly hidden by swelling; but more particularly marked are the signs of interference with the

function of the larynx, namely, severe dyspnea, which may be almost immediately fatal; painful and paroxysmal coughing, caused by the mechanical interference with respiration, by irritation of the larynx produced by the injury and by the aspiration of blood into the trachea and lungs. Swallowing is painful and difficult, but this symptom is not as marked as after fracture of the hyoid bone. If the mucous membrane is torn, there is steadily progressive emphysema, which travels down the neck, involves the thorax, the remainder of the trunk, and finally the extremities, and also extends down the intermuscular planes of the neck into the mediastinum, sometimes into the pleura, as well as upward into the face. The cough is accompanied by the expulsion of foamy blood from the mouth. There are changes in the voice, aphonia, and hoarseness. Death may occur from asphyxia, due to aspiration of large quantities of blood into the lungs, from mechanical interference with the passage of air through the larynx, or later from swelling and edema of the mucous membrane, which may occur at once or not come on for a number of days. These dangers are best met by an early tracheotomy. In mild cases all the symptoms will be less severe.

Fracture of the Cartilages of the Trachea.—Fracture of the cartilages of the trachea is less common than fractures of the larynx. It occurs usually as the result of severe crushing injuries of the neck. The trachea may be crushed from before backward or laterally, or torn across, or torn away from the larynx. The symptoms are the same as those of fracture of the larynx: emphysema is marked. The diagnosis is not easy on account of the deep position of the trachea, rendered still more inaccessible by the attendant swelling and emphysema.

Burns of the Neck.—Burns of the neck are chiefly interesting on account of the cicatricial contraction and resulting deformities which may follow these injuries.

Wounds of the Neck

Wounds of the neck occur most often as incised and stab wounds, as the result of attempts at suicide, less often as the result of homicidal assaults. Contused and lacerated and gunshot wounds are comparatively rare. The majority of suicidal wounds of the neck are made with razors, carving knives, and the like. They are incised wounds, usually in the upper part of the neck. In right-handed people they begin to the left of the middle line, and extend across the neck and downward to the right. The wound is usually more extensive to the left of the median line, and may here exhibit ragged tags of skin or one or more superficial parallel cuts in the skin. The cut may cross the middle line at any level, most commonly in the space between the hyoid bone and the thyroid cartilage, or through that cartilage or through the cricothyroid membrane, or more rarely below that point. These wounds are of any depth; they may open the pharynx or larynx or trachea, or divide these structures and the esophagus, together with numerous vessels, muscles, and

nerves. Usually the carotids and internal jugulars escape, on account of the protection afforded by the sterno-mastoids and the deep position of these vessels when, as is usual, the individual extends his neck when making the cut. More rarely, suicidal wounds are stabs intended to reach the large vessels. Homicidal wounds are usually stabs or incised wounds on the side of the neck.

Suicidal gunshot wounds of the neck are rare. I saw one case in which a young man shot himself with a .22 caliber pistol directly backward through the upper rings of the trachea. Aside from cough and bloody expectoration, some pain on swallowing, and subcutaneous emphysema of the neck, there were no serious symptoms, and he made a prompt recovery. The gravity of incised wounds of the neck depends upon hemorrhage, upon injuries to the air passages and esophagus, the nerves and muscles; further, upon aspiration of blood into the lungs, causing dyspnea or asphyxia; later, aspiration of wound discharges or food, and septic pneumonia, are common; further, upon wound infection and sepsis. If the wound is above the hyoid bone, and divides the muscles supporting the tongue, that organ may fall back upon the larynx and cause asphyxia.

I saw another gunshot wound of the neck, where a man was shot by another with a .22 caliber revolver, through the middle of the thyroid cartilage. The bullet apparently had passed directly backward. The patient suffered from scarcely any noteworthy symptoms other than hoarseness, and was soon entirely well. In another case, recently under my care, a man cut his wife's throat with a razor in a fit of jealous rage, also wounding her in other parts of the body. The wound in the neck was transverse, and extended across the neck from ear to ear at the level of the thyro-hyoid space, and opened the pharynx at this level for about an inch. The patient had bled rather freely, but suffered no other serious symptoms. Suture of the hole in the pharynx and of the divided muscles was followed by primary union. In several other cases, which I have seen, chiefly elderly lunatics who cut themselves in the throat with a razor, the pharynx has been widely opened; and, since these patients managed to tear off the dressings from time to time, and the openings in the pharynx were large, the wounds became infected and the patients died of septic pneumonia. (See, also, Esophagus.)

Injuries of Blood-vessels of the Neck in General.—The most serious symptoms of wounds of the neck are due to bleeding. If the wound is widely open, and neither the air passages nor the pleura are injured, the blood escapes outwardly. If the pharynx, larynx, trachea, or pleura are wounded, and more especially if the wound in the skin is small, much of the blood may enter the trachea and cause dyspnea, etc., or find its way into the pleura, or form a more or less extensive hematoma in the subcutaneous tissues and intermuscular planes of the neck, with serious or fatal pressure symptoms upon the larynx or trachea. Such pressure may, however, act to stop the bleeding, even from a large vessel, notably if it be not completely divided or the wound in its wall be longitudinal; the hematoma may then be absorbed and cure result. In other

cases infection of the hematoma exposes the individual to the dangers of sepsis and secondary hemorrhage. Further, the wound in the skin may heal, the wound of the artery may remain open, and an aneurism may result.

It is very important in wounds of the neck to determine the source of the bleeding—i. e., what vessel is wounded. In incised wounds this is not difficult; the wound lies open to inspection. In narrow stab and punctured wounds and in gunshot wounds the conditions are not so simple, and the surgeon may be deceived as to the gravity of the condition, notably if some time has elapsed since the receipt of the injury. The bleeding from a large vessel, artery, or vein may have been free at first, but with a considerable loss of blood and a weakened pulse; a small, continuous hemorrhage of no great amount may, nevertheless, represent the division of a large arterial trunk. If such a trunk is only partly divided, a systolic blowing murmur may sometimes be heard on auscultation. The formation of an arterial hematoma which showed, after a time, pulsation and a murmur, would indicate a similar injury. Absence of a temporal pulse in the presence of stab wound in the region of the common or external carotid would indicate division of one or other of these vessels, and a stab wound behind the clavicle would, in the absence of a radial pulse, indicate a division of the subclavian, but in neither case with any certainty. Surer and more satisfactory diagnostic measures are exposure of the bleeding point through a suitable incision, using the original wound as a guide.

Injuries of the Particular Vessels.—The innominate artery may be injured by gunshot wounds or by stab wounds at the root of the neck. The results are almost immediate death from external or intrathoracic hemorrhage. Wounds of the subclavian are rare on account of the protected position of the vessel. Stab and gunshot wounds have been the cause of the injury in the recorded cases. In most instances rapidly fatal bleeding has occurred before aid could be rendered. In other cases an aneurism has formed, and resulted fatally from one cause or another. The vein and the pleura are often wounded together with the artery.

The common carotid artery is wounded much more often than the subclavian; in not a few cases as the result of suicidal cuts; in these cases near its upper part, opposite the level of the larynx. When completely divided, death from hemorrhage is almost immediate. If the wound is a stab or puncture a fatal result may occur from the pressure of the effused blood upon the trachea. Less commonly the bleeding may cease and a cure result. The external and internal carotids are much more rarely wounded as the result of stab and gunshot wounds of the side of the neck, in some cases from the interior of the mouth. The bleeding is rapidly fatal unless controlled at once. The bleeding points, on account of the narrow space behind the jaw, are rather inaccessible. The branches of the external carotid may be wounded in cut-throat cases, often several branches at the same time. The bleeding is severe, and often speedily fatal if not controlled surgically. Wounds of the superior thyroid and of the thyroid gland itself bleed furiously. Wounds of the verte-

bral artery are not exceedingly rare, and are even more fatal than wounds of the common carotid, largely on account of the inaccessible position of the vessel. The artery may be wounded in any part of its course by a gunshot wound. Stab wounds are most common in the upper part of the vessel, near the atlas. The external wound may be in the back of the neck, or below and behind the mastoid process. When the wound is in front it may be hard to tell whether the vertebral or the carotid is injured. Search may be made for the so-called carotid tubercle on the transverse process of the sixth cervical vertebra, and pressure made backward, first above and then below the tubercle. If pressure below the tubercle stops the bleeding, the vertebral is probably wounded; if pressure above checks it, the carotid, because, above the sixth cervical vertebra, the vertebral is protected by the transverse processes of the upper vertebræ as it passes upward through the holes in these processes.

Wounds of Veins of the Neck.—Wounds of large veins in the neck are easy to recognize; the blood streams out steadily and rapidly, and in the case of the internal jugular is capable of causing rapid death from loss of blood quite as quickly as from division of a large arterial trunk. The same is true to even a greater extent of the innominate vein and of the subclavian vein. Open wounds communicating directly with these vessels are speedily fatal unless treated. If the wound in the skin is small so that the blood cannot freely escape, a hematoma may form and cause dyspnea or death from pressure. In conditions which interfere with the entrance of blood through the veins into the thorax, such as dyspnea from laryngeal obstruction or by pressure upon large veins at the entrance to the thorax by tumors or exudates, venous hemorrhage may be greatly increased, the veins are distended with blood, and, when wounded, the aspirating effect of the thorax being diminished or wanting, bleeding is very active.

Another accident, fortunately quite rare, is the aspiration of air into open wounds of the veins at the root of the neck. It is more apt to occur in widely open wounds, such as are made in surgical operations, than from stab wounds or other narrower wounds. The *symptoms* of such entrance of air are a distinctly audible sucking or gurgling sound, caused by the rapid passage of air through the opening in the vein, and, in cases where the amount of air is considerable, almost instantaneous stoppage of the heart, and death. In some cases the general symptoms may be postponed for several minutes. The patient then becomes very pale and, if conscious, has a feeling of intense anxiety and of choking; respiration becomes labored, the pulse rapid and fluttering; the pupils dilate; there may be convulsive movements, syncope, and death. Any of the large veins at the root of the neck, if wounded, may aspirate air in this manner, especially the internal jugular, the external jugular where it perforates the deep fascia, the innominate, the subclavian and axillary veins. Air may also enter much smaller veins if they are held open by attachments to fascia or by inflammatory exudates, or when the wall of the vein is thickened or rigid, as from infiltration with tumor tissue, so that they cannot collapse

when wounded. Fortunately, in a good many cases, even though considerable air has entered, there are either no symptoms, or such symptoms as arise are recovered from, the air being absorbed. Personally, although I have seen and heard air enter veins on several occasions, no serious symptoms have followed.

Injuries of the Nerves of the Neck in General.—Injuries of the nerves of the neck occur as the result of crushing injuries, as a complication of fractures of the clavicle, and from incised, stab, and gunshot wounds; secondarily, from pressure by displaced fragments of bone or from callus production, from the pressure of tumors or masses of cicatricial tissue or foreign bodies. Injuries of the cervical and brachial plexuses of nerves occur most often as the result of blunt violence applied to the side of the neck, sometimes associated with fracture of the clavicle. Less often, one or more of the cords of the cervical or brachial plexus may be divided in incised, stab, and gunshot wounds. The symptoms will vary according to the extent and location of the injury. The crushing injuries by blunt violence may merely contuse or stretch the nerves, or destroy one or more trunks completely. I have seen several cases in which, from blows and falls upon the shoulder and neck, without any external wound, the functions of nearly all the nerves of the brachial plexus were totally and permanently destroyed. The anatomical site of the plexus was occupied by a dense mass of cicatricial tissue in which no nerve elements could be traced. (See, also, Injuries of the Upper Extremity.)

In the different cases, from whatever cause, the paralytic symptoms, motor and sensory, will vary according to the seat and extent of the lesion. At the time of the injury there is generally severe pain; the paralyses due to nerve destruction are present at once. In cases of contusion of the nerves merely, the paralysis may be incomplete, and be accompanied by symptoms of irritation —twitching of certain muscles, paresthesiæ, neuralgic pains, and disturbances of sensibility without complete anesthesia. Usually the motor paralysis is more complete than the sensory. If the nerve trunks have been entirely divided or destroyed, the paralysis is permanent. In certain cases, after the paralysis has existed for a certain time a traumatic neuritis may be developed in the injured nerve trunks, and may spread to other nerves which anastomose with those which have been injured. There will then be added pain and further paralyses affecting the uninjured nerves the seat of neuritis.

In some cases—notably those produced by the pressure of bony fragments, by callus production, by the presence of foreign bodies, or the development of masses of cicatricial tissue which press upon the nerve trunks, the paralysis will tend to be more marked as the pressure increases. In these cases, also, a neuritis may be developed as the result of pressure. As the result of permanent loss of function in the nerves there will be developed atrophic and degenerative changes in the muscles, and trophic changes in the skin of the extremity, such as have already been described under Injuries of Nerves. It is generally impossible to say in the given case, without operative exposure of the injured

nerves, to what extent regeneration of the injured nerve trunks will take place. I saw one case of a stab wound high up in the axilla, which divided all the cords of the brachial plexus; the atrophy of the arm was complete and permanent; in spite of several carefully planned operations for the restoration of the divided nerves, no return of function followed. (See Injuries of Nerves, Vol. III.)

Injuries of the Individual Nerves of the Neck.—*Injuries of the Pneumogastric Nerve.*—The pneumogastric nerve is occasionally wounded or pinched by an artery clamp or a ligature during surgical operations upon the neck, notably in the extirpation of tumors, rarely ligation of the common carotid artery. In operations upon the thyroid gland the recurrent laryngeal nerve may be torn or pinched, or included in the ligature surrounding the inferior thyroid artery. Fractures of the base of the skull sometimes injure the pneumogastric. There may be an associated lesion of the glosso-pharyngeal. Division of the pneumogastric nerve of one side in the neck will produce symptoms which appear to be, in most instances at least, grave dangers to life. If the nerve is merely pinched with an artery clamp, sudden symptoms of collapse may occur, such as sudden failure of respiration or of the heart action. In the reported cases these symptoms have, however, disappeared when pressure upon the nerve ceased or suitable stimulation and artificial respiration were used. Division of the nerve does not appear to affect the pulse or respiration materially, although in some cases a rapid pulse has been observed for a time. Its accidental or intentional division has usually occurred during the removal of malignant growths of the neck; and although death has followed in about half the cases, it has seemed to be due to causes other than the injury to the nerve. The only constant symptoms are due to the division of the fibers belonging to the recurrent laryngeal nerve, namely, paralysis of one vocal cord and the resulting hoarseness or, in some cases, aphonia.

Division of the pneumogastric above the origin of the superior laryngeal nerve causes, in addition, anesthesia of the corresponding half of the larynx. Division of both pneumogastrics in the neck causes total paralysis of both vocal cords, a rapid pulse, changes in the breathing—either increased or diminished frequency—and death from edema of the lungs or pneumonia. Irritation of the pneumogastrics causes, as its most notable symptom, a slow pulse.

Injury of the Sympathetic Cord in the Neck.—Division of the cervical sympathetic scarcely occurs as an isolated accidental injury. As an associated injury it has been occasionally observed. Paralysis is more often due to pressure from tumors. In one case of my own it appeared to be accompanied by fibrous thickening of the sheath of the nerve, and was associated with trigeminal and occipital neuralgia. The symptoms of paralysis of the cervical sympathetic are slight sinking in of the eyeball, loss of the cilio-spinal reflex, a contracted pupil on the affected side, partial ptosis, flushing of half the face, an increase in temperature, and sometimes sweating of the skin of the face on the affected side. Irritation of the cervical sympathetic

causes a dilated pupil, sometimes exophthalmos and elevation of the upper lid so that the eye appears prominent and larger, paleness and coldness of the corresponding side of the face.

The Hypoglossal Nerve.—The hypoglossal nerve may be injured in cut-throat cases, and rarely in surgical operations by carelessness. I have seen a ligature put around it by a gentleman who was seeking the lingual artery. The symptoms produced by its division are unilateral motor paralysis of the tongue. In some cases hemiatrophy of the tongue.

Division of the Phrenic Nerve.—Division of the phrenic nerve causes paralysis of one half of the diaphragm; division of both phrenics, immediate death by respiratory failure. The division of one phrenic is followed by one notable symptom—i. e., dyspnea on exertion. Death has occurred in a few cases (ligation of third part of the subclavian). Irritation of the phrenic causes spasmodic coughing and hiccough.

Division of the Spinal Accessory Nerve.—Division of the spinal accessory nerve in front of the sterno-mastoid behind the angle of the jaw causes sometimes paralysis of the sterno-mastoid and trapezius muscles, followed by atrophy. In other cases the latter muscle receives a sufficient innervation from other sources and retains its function wholly or partly. When paralysis and atrophy follow the division of the nerve, the unopposed action of the muscles of the opposite side causes a more or less marked paralytic wry-neck. The shoulder droops, and with the scapula falls forward. The power of lifting heavy weights is lost. (See Injuries of the Upper Extremity.)

The Posterior Thoracic Nerve, Supplying the Serratus Magnus Muscle.—The posterior thoracic nerve is occasionally injured alone by injuries in the neighborhood of the shoulder, and is sometimes cut accidentally during operations in the axilla, especially during the complete operations for carcinoma of the breast. The resulting paralysis causes the scapula to hang backward and to flare away from the chest wall in a characteristic manner. (See Upper Extremity.)

Injuries of the Thoracic Duct.—Injuries of the thoracic duct are exceedingly rare as isolated accidental injuries, and are usually complicated by wounds of the neighboring blood-vessels so that the signs of injury of the duct are overshadowed by bleeding and other symptoms. Wounding of the duct near its ordinary point of entrance into the angle between the left subclavian and internal jugular veins is by no means uncommon during the extirpation of tumors and tuberculous lymph nodes at the root of the neck. The injury is to be recognized by the escape of abundant, more or less turbid or milky white fluid into the wound and the recognition of the slit or puncture in the wall of the duct. I have seen this accident happen four times. In three cases the opening was successfully closed by suture; in the fourth case (one of carcinomatous glands in the subclavian triangle) I sutured the slit in the duct twice unsuccessfully, and finally applied a firm pad in the supraclavicular region, under which the wound in the duct healed.

Wounds of the Esophagus.—Wounds of the esophagus rarely occur alone as the result of external wounds; other important structures are commonly injured. If the wound is a widely opened, incised wound, the diagnosis can be made by inspection; otherwise the recognition of the condition must depend upon the symptoms, often not clear. Such symptoms are, in typical cases, pain and difficulty in swallowing, regurgitation of food or vomiting of blood, and the escape of mucus, or of solids or fluids swallowed, from the external wound. The lower the position of the wound the greater the danger of the escape of infectious material into the mediastinum or pleura, to be followed by a septic mediastinitis, or pleuritis and death. The esophagus may be wounded from within by sharp foreign bodies swallowed, and if these become impacted, they also may ulcerate into the pleura, mediastinum, or trachea, and cause septic inflammation, or, if into the trachea, strangulation or septic pneumonia. (For further details, see Esophagus.) Severe hemorrhage may occur from ruptured varicose veins of the esophagus, spontaneously or as the result of vomiting, notably in drunkards. I have a patient who has twice nearly bled to death in this manner. I have had him under observation for fifteen years. The symptoms are vomiting of blood. As the result of violent vomiting in such cases the esophagus may be ruptured near the cardia, with fatal results. (See Diseases of the Esophagus.)

Burns of the Esophagus.—Swallowing hot liquids, strong acids, and alkalies, and notably carbolic acid, causes burns of the esophagus of greater or less severity. The symptoms of such burns and the extent of the injury vary according to the character, quantity, and concentration and temperature of the liquid swallowed. In bad cases the mucous membrane of the mouth, throat, esophagus, and stomach are deeply destroyed. Speedy death from shock is not rare in these cases. Perforation of the stomach, and death from peritonitis or infection and phlegmonous inflammation of the wall of the stomach, are not infrequent. In the less severe cases the signs and symptoms are, evidences of burns in the mouth and pharynx, pain in the esophagus and stomach, vomiting, retching, hiccough, inability to swallow, and prostration; sometimes edema of the glottis. Wounds and burns of the esophagus are quite commonly followed by stricture. (See Injuries and Diseases of the Esophagus.)

INFLAMMATORY PROCESSES OF THE NECK

The Tissues of the Neck.—Acute and chronic inflammatory processes of the most varied character occur in the tissues of the neck with great frequency. The anatomical arrangement of the fascial and connective-tissue planes of the neck is such that suppurating foci in certain situations advancing along the lines of least resistance tend to spread in definite ways. The arrangement of the lymphatics of the neck, also, has an important bearing on the successvie involvement of different areas.

The following anatomical details are adapted from Merkel's "Topographical Anatomy": The skin of the neck is firmly adherent to the platysma myoides, any inflammatory focus in the substance of the skin, and superficial to the platysma, tends to remain distinctly localized. Beneath the platysma is a layer of loose connective tissue; a purulent focus in this layer may spread up and down the neck, even on to the thorax, but shows no marked tendency to invade the deeper structures except through the lymphatics.

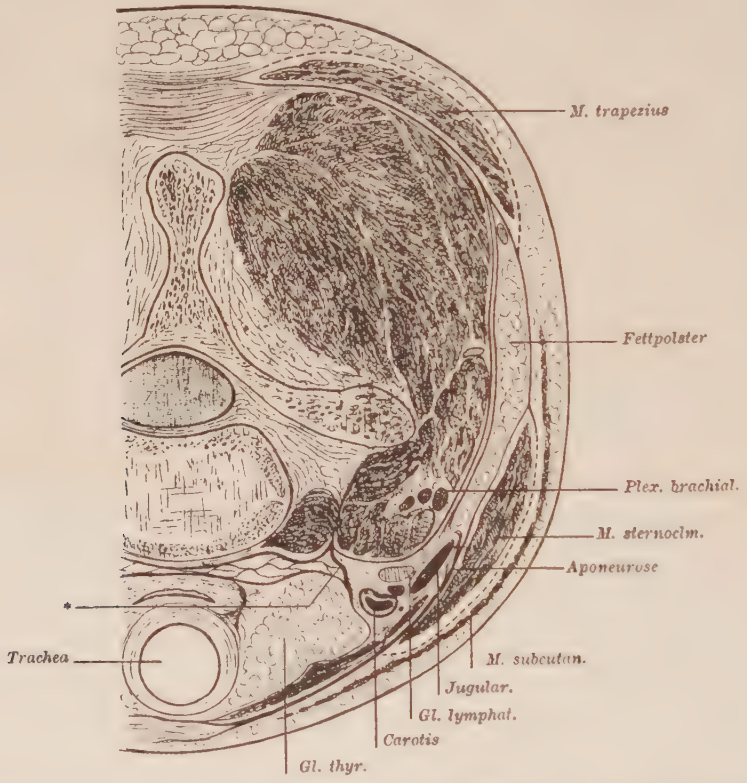


FIG. 191.—A HORIZONTAL SECTION OF THE NECK AT THE LEVEL OF THE UPPERMOST RING OF THE TRACHEA, SHOWING THE FASCIAL LAYERS OF THE NECK. *indicates the fibrous layer which includes the vertebral artery. The delicate connective-tissue planes which overlie the sternocleidomastoid muscle and the trapezius are designated by broken lines. The pneumogastric nerve which lies behind the carotid and the hypoglossal nerve which passes in front of it are not indicated. (Merkel topographical anatomy.)

Merkel distinguishes a deep fascia of the neck and a separate aponeurotic layer covering the muscles. The deep fascia is a connective-tissue sheath which covers the prevertebral muscles, and in the lateral region of the neck passes into the connective-tissue sheath of the great vessels. The "neck aponeurosis" is a firm layer of connective tissue extending from the hyoid bone to the sternum and clavicle. It is inserted into the sternum by two lamellæ, an anterior and a posterior, to the anterior and posterior borders of the sternum respectively, inclosing a small space filled with loose connective tissue—"the

suprasternal intra-aponeurotic space." Purulent foci in this space remain localized. The aponeurosis covers the muscles attached to the hyoid bone in the middle line. Laterally, above the tendinous portion of the middle of the omohyoid muscle, it passes into and is lost in the sheath of the great vessels. Below this point it surrounds the omohyoid. Laterally this layer passes beneath the sheath of the sterno-mastoid. The great vessels lie immediately beneath this layer. The vein alone is intimately adherent to the apneurosis. The arteries, nerves, and lymph vessels are surrounded by a layer of loose connective tissue, attached posteriorly to the spinal column, and passing into the deep or prevertebral fascia. Above the hyoid bone there is a firm layer of connective tissue passing from the lower border of the jaw, and, laterally, covering the sterno-mastoid muscle. This layer forms the so-called *connective-tissue capsule* of the submaxillary gland.

Between the various fascial layers of the neck, and in relation with the blood-vessels, the trachea, and the esophagus, are certain planes of loose connective tissue, the primary purpose of which is to permit that free mobility necessary to enable the various structures to move easily in carrying out the complex and varied motions of the head and neck. These spaces are five in number: First, the retrovisceral space. Second, the previsceral space. Third, the space for the vessels. Fourth, the suprasternal intra-aponeurotic space. Fifth, the capsule of the submaxillary gland.

First.—The retrovisceral space lies between the pharynx and esophagus in front, and the anterior surface of the spinal column behind. It begins above, at the base of the skull, and extends downward into the thorax, as far as the ninth or tenth dorsal vertebra. Laterally it extends outward as far as the sheath of the vessels. *Second.*—The *previsceral space* lies between the anterior surface of the trachea and the muscles which ascend to be attached to the hyoid bone, it is covered in front by the aponeurotic layer already described; extends downward into the anterior mediastinum and reaches laterally as far as the sheath of the vessels. The sheath of the vessels on either side forms the boundary between the anterior and posterior space. *Third.*—The *space surrounding the great vessels* is very important in relation to the extension of the inflammatory processes on account of the great number of lymphatic glands and channels which it contains, and the rather firm character of its connective-tissue boundaries, which tend to limit the spread of infectious processes, so that they rather extend within the sheath itself toward the mediastinum than spread into the surrounding tissues. *Fourth.*—The *suprasternal space* extends from the sternum upward as far as the isthmus of the thyroid. *Fifth.*—The *submaxillary space* exists because the submaxillary gland does not completely fill the submaxillary triangle formed by the bellies of the digastric and the border of the jaw. A small space exists both in front of and behind the gland, filled with loose connective tissue, containing fat. The posterior border of the mylohyoid muscle extends posteriorly into this space. The space is bounded outwardly by a dense layer of connective-tissue covering in the gland, and extend-

ing from the border of the jaw to the hyoid bone. Internally this connective-tissue layer is attached to the wall of the pharynx, to the tonsil, and to the sublingual gland.

The important facts to be remembered in regard to these spaces are that the anterior and posterior spaces—previsceral and retrovisceral, respectively, and the space surrounding the vessels—communicate freely below with the thorax, and thus with one another. Above the arch of the aorta the trachea passes backward from the anterior to the posterior space, so that an infectious process extending down the trachea may find its way into both anterior and posterior mediastina. It is also to be remembered that suppurative processes in the neck may extend along the sheaths of both vessels and nerves downward and outward into the axilla. The platysma and the skin being closely attached, and forming together a firm dense layer, afford considerable resistance to the outbreak of deep-seated suppurative processes through the skin in the lateral regions of the neck.

The Lymph Glands of the Neck.—The lymphatic glands of the neck may be divided into several groups: *First.*—The *submaxillary lymphatics*, quite numerous and scattered throughout the tissues of the submaxillary triangle. One or more is usually found along the border of the jaw, and a number exist in the loose connective tissue between the jaw and the mylohyoid muscle. A few are found inside the capsule of the gland, but not in the gland itself. These lymphatics receive the lymph from the face, from the interior of the mouth, the teeth, the jaw, the tongue, and the pharynx. *Second.*—The *submental lymphatics*, few in number. They lie in the connective tissue beneath the chin. They receive the lymph from the lower lip, the chin, and the anterior portion of the tongue, and are frequently *the first glands to become enlarged in cancers and other infectious processes of these regions.* They empty into the submaxillary lymphatics. *Third.*—The *superficial cervical lymph glands.* These glands, five or six in number, lie upon the surface of the sterno-mastoid muscle and along its posterior border. They are covered by the platysma, and receive the lymph from the skin of the neck, the nape of the neck, and the external ear. They communicate with the deep chain of lymphatics. They are often enlarged during the early stages of secondary syphilis. *Fourth.*—The *deep cervical lymph nodes* are numerous, fifteen to twenty in number. They extend along the course of the great vessels from the base of the skull down to the supraclavicular fossa. They may be divided into an upper and lower set. The upper glands are always represented by one or more nodes lying in the bifurcation of the common carotid artery. They receive lymph from the palate, the nasal fossæ, the pharynx, the larynx, the tongue, and the tonsils. The more posterior glands receive lymph from the interior of the cranium, the deep muscles of the neck, and the lowest portion of the pharynx. The lower set of glands lie along the lower portion of the great vessels and in the supraclavicular fossa upon the scaleni muscles and along the cords of the brachial plexus. They receive lymph from the superior chains and from the neighboring skin and

muscles, also from the trachea, lower portion of the larynx, the esophagus, and the thyroid gland. They communicate with the lymphatics of the axilla and thoracic walls.

The lymphatic vessels after leaving the lower chain unite into a large trunk, which empties into the thoracic duct on the left side. On the right side, into the lymphatic ductus communis, or directly into the venous circulation at the junction of the subclavian and internal jugular veins. The suboccipital glands lie upon the origin of the trapezius muscle and receive lymph from the occipital muscle and back of the head. There is usually one gland over the origin of the sterno-mastoid muscle. This receives lymph from the posterior part of the external ear and neighboring portion of the scalp, and empties into the superficial chain of lymphatics in the neck.

Acute Suppurative Processes of the Neck.—The acute suppurative processes of the neck occur most commonly during childhood, adolescence, and early adult life—caries of the teeth, infectious processes in the mouth, the jaws, and the integument of the head and face being more frequent during the first thirty years of life than later. While these suppurative processes show every possible variation in intensity, they are, in the majority of cases, localized rather than spreading infections, and commonly end in the formation of an abscess rather than in a spreading phlegmonous process. They affect, in a large proportion of cases, the submaxillary region; further, the loose connective-tissue planes already indicated. Many of these abscesses arise from lymph nodes, either superficial or deep, as the result of infection of the lymph channels leading to the gland, from the most varied causes. In children especially, from infection through carious teeth and suppurative periostitis of the jaw, frequently from infection of the mucous membrane of the mouth and the tonsils. As secondary infections in the course of acute infectious diseases—the exanthemata, typhoid, diphtheria, etc. Further, as the result of infection of the salivary glands under similar conditions; also as the result of cutaneous infections following eczema of the face and scalp, furunculosis, and pediculosis capitis.

Fig. 192.—Acute Abscess in the Submaxillary Region. (Author's collection.)

We have already indicated the course and symptoms of *abscess* and of *phlegmonous inflammation in the submaxillary region* under Diseases of the

Salivary Glands. Here it may be added that in the majority of cases the process lies outside the inclosing fibrous envelope of the submaxillary gland itself, and runs its course as an acute abscess, giving perfectly plain indications of its character without grave constitutional disturbance, and finally breaking through the skin if not incised. If the infection is *confined within the fibrous envelope of the gland*, the signs and symptoms of a grave constitutional and local infection are much more marked. The process often takes on a sloughing and gangrenous character. The submaxillary gland itself usually remains intact, the purulent or necrotic inflammation being confined to the surrounding connective tissues. The mucous membrane of the mouth, pharynx, and larynx are often infiltrated and edematous. Inability to open the mouth, difficulty in swallowing, speaking, and severe dyspnea may be present. The head is held rigidly bent toward the affected side. Salivation and a fetid odor of the breath are marked. In untreated cases death may occur in a few days from septic poisoning. (With all the attending symptoms characterizing this condition, see Septicemia.) The Streptococcus, or Staphylococcus pyogenes aureus, or both, or one or other of these with the Pneumococcus or Bacillus coli, may be found in cultures from the pus. Increase in the large polynuclear leucocytes is especially marked. In some cases death may occur from asphyxia due to edema of the glottis. The *local signs* are easily distinguished, the whole upper part of the neck on one side is hard, tender, painful, and greatly swollen. The tongue is forced upward against the roof of the mouth. The skin may be normal in color early in the disease; later it becomes red, or deep mahogany-red as the infection approaches the skin surface.

Abscesses at the Angle of the Jaw.—Abscesses at the angle of the jaw occasionally occur from infectious processes connected with the posterior molar teeth. The most notable symptom, other than that of an acute abscess, consists of inability to open the mouth.

Abscesses of the Submental Lymph Nodes.—Abscesses of the submental lymph nodes may occur from infection of the lips, the chin, the floor of the mouth, and front of the tongue. The resulting abscess forms a tender, red, prominent, sometimes fluctuating, swelling under the chin, and remains localized without tending to spread widely.

Abscesses Arising in the Deep Lymph Nodes of the Neck.—Abscesses arising in the deep lymph nodes, notably in the glands of the upper set which lie near the bifurcation of the carotid, are less common than those in the submaxillary region. They occur from similar kinds of infection, during convalescence from the exanthemata, especially scarlet fever, from carious teeth, mastoiditis, inflammation of the middle ear, infectious processes of the nose, ozena, stomatitis, etc.

The infection is characterized by general symptoms of sepsis and by the formation of a brawny, hard, tender, painful swelling, which lies beneath the sterno-mastoid and raises that muscle from its normal position. The head is inclined toward the affected side. The inflammatory infiltration often ex-

tends to the interior of the mouth and pharynx, and produces the symptoms already described. The process may end in resolution; usually, an abscess forms which may point at the anterior or posterior border of the sterno-mastoid, or perforate the deep fascia and spread up and down the neck beneath the platysma. In some cases the pus travels down in the sheath of the vessels and into the axilla, in others downward into the mediastinum with the production of fatal suppuration, or septic pleuritis, or pericarditis, or pyemia, and death from general sepsis. Occasionally such an abscess may rupture into the pharynx, or more rarely into the trachea. One of the less common results of these abscesses is ulceration and perforation of the walls of the blood-vessels with fatal hemorrhage; any one of the important arteries of the neck may be opened in this way. If the abscess is already open outwardly, the bleeding is external. If not, then internal into the abscess cavity, into the mediastinum, pleura, pericardium, etc. When the septic process involves the wall of a vein, septic thrombosis of the vein results, with its attendant danger of pyemia.

In operating upon these cases it is the duty of the surgeon, when the character of the infection is severe and shows a distinctly progressive tendency, to make such incisions as will render any further burrowing and extension of the process from retention of pus, or from the existence of a dependent pocket, or from imperfect relief of tension absolutely impossible. To illustrate what I mean, I may say that in bad cases of this sort I have sometimes made a curved incision, convex downward, beginning near the middle line, beneath the chin and crossing the level of the hyoid bone to end beneath the ear, and joined it near its middle by an incision extending downward, parallel to the sterno-mastoid muscle, ending at the clavicle; the infiltrated area was thus opened throughout its entire length, and all danger of pocketing and tension was relieved. The resulting scars have not been disfiguring, and the operation has been followed by immediate relief of threatening symptoms. When the pus burrows into the axilla, local pain, swelling, and edema, pain on raising the arm, etc., will be present. Sometimes fluctuation may be detected above and below the clavicle. But in the diagnosis of all these deep-seated purulent processes, the local signs are usually those of a boardlike, dense infiltration. Fluctuation is usually a sign developed later, if at all, and one for which no good surgeon waits before making suitable incisions.

Abscesses in the Supraclavicular Region.—Abscesses in the supraclavicular region may originate in the lymph nodes of that region, or develop as an extension of the processes just described. They may break through the deeper fascial planes and appear as fluctuating abscesses beneath the platysma, or burrow in one or other of the directions already indicated. It is to be remembered that an early diagnosis and appropriate treatment in all these cases is of the utmost importance, since, in many instances, the inflammatory process is distinctly circumscribed and, if opened early, will remain so. If, on the other hand, temporizing measures are used, the dangers of a spreading

septic process are very great. In the absence of fluctuation, a point of extreme local tenderness in the hard and swollen area, a center of intense redness which shades off into the surrounding skin, a localized doughy condition in the center of a hard infiltrated mass, are good guides for the knife.

Retropharyngeal Abscess.—Suppuration in the retrovisceral space, between the pharynx or esophagus and the anterior surface of the bodies of the vertebræ, occurs as an acute process less commonly than in the other spaces. It is more common among infants and children than among adults. The infection occurs as the result of wounds of the pharynx and esophagus, from ulceration caused by the pressure of a foreign body, as a complication of the exanthemata, notably scarlet fever in young infants between one and three years old. Such an abscess may also follow diphtheria, erysipelas, or any ulcerative process of the throat. The infection may take place through the lymphatics of the pharynx or of the nasal fossæ. Very often the process originates in the lymph nodes at the level of the second or third cervical vertebra. The pus collects between the posterior wall of the pharynx and the spinal column, and may spread downward into the posterior mediastinum, more rarely into the sheath of the great vessels, occasionally, thence, into the axilla or toward the surface either in front of or behind the sterno-mastoid. Still more rarely in the parotid region.

The *signs* and *symptoms* of acute retropharyngeal abscess are, in addition to the constitutional symptoms of sepsis, due largely to the mechanical interference with swallowing and breathing caused by the bulging forward of the posterior pharyngeal wall. There is pain in the back of the throat. If the abscess is high up in the pharynx, the patient breathes through the opened mouth on account of the closure of the posterior nares by the pharyngeal tumor. During sleep, if the mouth closes, an attack threatening death from asphyxia may occur. There is increasing difficulty, and finally inability to swallow. Speech is interfered with, the voice is thick and of a nasal quality. There is gradually increasing dyspnœa. The head is held immovable and a little extended. External inspection and palpation may reveal tenderness, swelling, and infiltration on one or both sides of the neck behind the angle of the jaw, or in the submaxillary region, or lower down. In adults inspection of the throat will show a bulging of the mucous membrane of the pharynx, either median or more marked on one side, the mucous membrane may be smooth, shining, and red, or red and edematous, or normal in appearance. Inspection through the mouth is difficult or impossible in infants, and the most important diagnostic signs are to be recognized by palpation of the pharynx with the forefinger introduced into the mouth. The bulging of the posterior pharyngeal wall forward is thus easily detected, and usually fluctuation as well. If these abscesses burst into the pharynx death may occur from aspiration of pus into the trachea and asphyxia, or later on from septic pneumonia. If the abscess approaches the skin surface it will give corresponding signs—i. e., infiltration, induration, tenderness, sometimes redness of the skin and fluctuation.

Infection of the mediastinum will produce the symptoms of fatal sepsis, or purulent pleuritis, or pericarditis, as the case may be.

Chronic Abscesses of the Retropharyngeal Space.—Chronic abscesses of the retropharyngeal space are, for the most part, due to tubercular caries of the bodies of the cervical vertebræ. They will be discussed under the diseases of the spine.

Chronic Inflammations of the Neck.—Chronic inflammations of the neck are most often caused by tuberculosis and other chronic inflammations of the cervical lymph nodes, by syphilis, and actinomycosis. Certain other affections will also be considered.

Actinomycosis. (See Actinomycosis.)

Inflammatory Hyperplasia of the Cervical Lymph Nodes.—During the early years of life up to the tenth year, catarrhal inflammations of the mucous membrane of the nose and throat, tonsillitis, caries of the teeth, furuncles and small abscesses of the face, inflammations of the ear, the acute exanthemata, irritations and infections of the skin, and of the face and scalp are exceedingly frequent. After this age their frequency gradually diminishes until adult life, when they are notably less common than during childhood. As the result of these external irritations there occur infections of the cervical lymph nodes of various kinds and degrees. In many instances the infection is caused by pus microbes in sufficient number and virulence to produce suppuration of the gland tissue and a localized abscess, as already described. In other instances the process stops short of suppuration, the tenderness of the gland disappears, but the gland remains enlarged for some time, or even permanently. In still other cases no acute inflammation precedes; in the presence of some chronic source of irritation one or more lymph nodes become painlessly and chronically enlarged. In any of these cases, a removal of the source of irritation or infection may be followed by a gradual diminution in the size of the gland until it regains its normal size. This condition of the lymph nodes is known as *inflammatory hyperplasia*, and such glands possess the following characters: They vary in size from that of a pea to a hazelnut; they are of moderately firm consistence, neither very hard nor very soft; they are neither tender nor painful; they are freely movable; they do not tend to increase in size nor to undergo degenerative changes of any sort. They give rise to no symptoms, except possibly deformity, and would be of no particular surgical interest were it not for the fact that it is not always easy to distinguish them from lymph glands the seat of tuberculosis before the latter have undergone degenerative changes. If, in the presence of some local source of irritation—a carious tooth, pediculosis capitis, hypertrophied tonsils, an eczema of the nose or the ear, etc.—we find one or more lymph nodes enlarged in a child's neck without local pain or tenderness, we must try to distinguish between these two conditions—*simple inflammatory hyperplasia and tuberculosis.* If we remove the local source of irritation and the gland grows smaller, or disappears, or remains entirely quiescent for some time, it is probably not tuberculosis. If it grows larger,

or if other glands become enlarged, or if the gland softens or becomes adherent to the surrounding structures, it is usually due to tuberculosis. In case of doubt, it is far better to remove one or more glands for inspection and microscopic examination and settle the diagnosis once and for all, so that the glands, if tubercular, may be promptly removed.

Tuberculosis of the Lymph Glands of the Neck.—Tuberculosis of the lymph nodes is one of the most frequent forms of tubercular disease, and the lymph nodes of the neck are the seat of the process in about ninety per cent of lymphatic tubercular infections. The disease is most frequent between the fifteenth and thirtieth years of life, but may occur at any age. An hereditary tendency to tubercular infection is present in a considerable proportion of cases. Bad hygienic surroundings, improper food, overcrowding, overwork, etc., cause the disease to be much more frequent among the poor than among the well-to-do. A considerable proportion of those who suffer from tubercular glands of the neck die of pulmonary phthisis, or from acute general miliary tuberculosis. Infection takes place through the mucous membrane of the throat, mouth, and nose, or through the integument of the face and neck. A less common avenue is through the mucous membrane of the bronchi, causing tuberculosis of the bronchial glands and an ascending infection to the cervical lymph nodes. Usually the infection advances downward from the upper to the lower cervical glands. Carious teeth and the tonsils are thought to be the two most common avenues for the entrance of tubercle bacillus in these cases. Hypertrophied tonsils are known to be the home of the tubercle bacillus in many instances. Trifling lesions of the skin and mucous membrane of all kinds afford an avenue of entrance for the bacilli, whence they reach the lymph nodes, and under favorable local and general conditions are enabled to grow and thrive. The acute infectious diseases of childhood—typhoid, etc.—all predispose to the occurrence of tubercular infections. Primary tubercular ulcerations of the skin or mucous membrane may be followed by tubercular infection of lymph nodes, but such an occurrence is rare in comparison with the number of cases in which the bacillus leaves no trace at its point

Fig. 193.—Tuberculous Lymph Nodes of the Neck, Showing Periglandular Infiltration. (New York Hospital, service of Dr. Murray.)

of entry, but first makes its presence evident in the lymph nodes. The disease may affect one gland or one group of glands, or several groups on the same side, or on both sides of the neck. The infection may slowly travel from one gland to another until many are involved, or an entire group may be infected at once. Clinically the disease presents itself in a number of types; the characters of each are, however, often combined in the same case. We may distinguish (I) cases in which the infection remains confined to the gland tissue proper; (II) cases in which the infection extends to the periglandular tissues.

Fig. 194.—Tuberculous Lymph Nodes, Deep Cervical Chain beneath the Sternomastoid Muscle. (Author's collection.)

Class I. *Cases in which the Infection Remains Confined to the Gland Tissue Proper.*—In some cases the infection is confined to a single gland, or to a small group of glands, and the clinical picture will vary according to the activity of the tubercular process. The glands in the upper part of the neck are often the seat of the disease; the submaxillary region at the angle of the jaw, under the chin, in front of the ear, in the parotid gland, or in the supraclavicular fossa. The tumor is rounded or ovoid, painless and insensitive, moderately firm, movable, and may be as large as a hazelnut, seldom larger than a walnut; careful examination will often detect other smaller glands in the same region. It may be stated here, as a matter of general experience, that upon operation, the number of glands involved will almost always be found more numerous and their distribution more extensive than could be determined by external palpation. The superficial glands alone are felt. At the operation many glands are found to be involved. The surgeon, therefore, plans his incisions accordingly, and makes his cut in such a direction that it can be freely enlarged should occasion require. Infection of an entire group of glands is much more common than that of a single gland. A conglomerate mass of enlarged glands can then be distinguished movable on the surrounding parts, and of variable size and shape, of hard or soft consistence, occupying some part of the neck. The individual glands can often be distinguished. In other, and not uncommon, cases several groups of glands on one or both sides of the neck will form masses or chains of glands, often of considerable size, causing marked deformities.

The *history* is of the slow, or rather rapid, or intermittent increase in size in one set of glands after another, extending over months or years. The glands are painless and insensitive. Pressure symptoms are usually wanting. In the majority of cases the general health is not seriously interfered with; the patients may appear to be in fair general health or, on the other hand, they may be more or less anemic. If pulmonary phthisis or other tubercular lesion coexists, it will produce its own symptoms. There is, however, a certain set of cases where many glands are successively involved, and usually, also, glands in other regions than the neck—the axillæ, groins, retroperitoneal glands, etc.—in which the patients have from time to time attacks of high fever, lasting for days or weeks. These are the cases in which the course of the condition is that of Hodgkin's disease, with a fatal issue, as already described.

FIG. 195.—TUBERCULOSIS OF THE LYMPH NODES OF THE NECK, PERIGLANDULAR INFILTRATION AND DIFFUSE ABSCESS INVOLVING THE DEEP CONNECTIVE-TISSUE PLANES OF THE NECK. (New York Hospital, service of Dr. F. W. Murray.)

Differential Diagnosis.—Tuberculous glands of the neck, however extensive, may be differentiated from leukemia by an examination of the blood; from primary sarcoma of the lymph glands by bacteriological examination of the excised glands, and inoculation of susceptible animals. The pathological lesions found in these generalized tuberculous lymph nodes vary much in different cases. There may be distinguished:

A. A *purely hyperplastic form*, most common in the cases running the course of an acute fatal pseudoleukemia. The glands are enlarged and of moderately firm consistence; on section they appear as a simple increase of gland tissue, and show neither tubercles nor caseation. Under the microscope evidence of tuberculosis is usually wanting, although in some cases tubercle bacilli may be found in small numbers. Inoculation of animals with the glandular substance is usually necessary to establish the diagnosis. These rapidly growing hyperplastic lymph nodes differ in no way under the microscope from primary lymphosarcoma, and it must be confessed that at present the pathology of these conditions is still obscure.

B. *Hyperplastic inflammation of the glands with the formation of larger or smaller tubercles.* The glands are enlarged or normal in size. Upon the grayish-red, cut surface, larger or smaller grayish dots or areas can be distinguished, sometimes occupying a considerable part of the gland. Under the microscope they are recognizable as tubercles and areas of tubercular granulation tissue. Bacilli are few in number.

C. *Caseation.* Degenerative changes take place in the tubercle tissue, and produce caseous areas in the gland. These may be large or small, of pinhead size, or may occupy the entire gland; of firm, soft, and crumbly, or fluid consistence. Such caseous areas may, after a time, undergo calcification. The color of the caseous areas is yellow, yellowish-white, or white. If fluid, the microscopic appearances will be that of a liquid containing abundant fat drops, fatty and granular degenerated cells, and granular detritus. Tubercle bacilli are few in number. Inoculation of susceptible animals produces tuberculosis.

Class II. *Cases in which the Infection Extends to the Periglandular Tissues.*—In these cases the capsule of the gland is at first thickened, and later forms adhesions to the surrounding structures of whatever kind. Sooner or later perforation of the capsule takes place, and the broken-down tuberculous material is poured into the surrounding tissues. Thus diffuse tuberculous inflammations may occur in the connective-tissue planes, or, what is more common, the infection advances toward the surface with the formation of a tuberculous abscess. The skin at first becomes adherent, then infiltrated, livid in color, thinned, and finally ruptures, giving escape to tuberculous cheesy material and fluid resembling pus in appearance. There is left behind a cavity lined by velvety tubercular granulation tissue or caseous material. The skin edges of the opening are thinned out and undermined, red or blue in color. Such an orifice may increase in size by ulceration, and remain open indefinitely, or gradually heal down to a tuberculous sinus, or after a time heal entirely, leaving behind a depressed, puckered scar, often with radiating bars of cicatricial tissue around its circumference. In many cases, after the skin is perforated, pale fungating granulations sprout from the edges of the orifice, producing the characteristic appearances of a tuberculous sinus.

Infection of the periglandular tissues with pyogenic microbes is not an uncommon accident either before or after perforation of the skin. If the infection takes place before the skin is involved, the course of the infection is that of an acute abscess of the neck, and the diagnosis may only be made when, upon incising the abscess, caseous masses escape. Such infection may be curative; the tuberculous focus may be entirely cut off from the surrounding tissues and appear as an entire gland, or as caseous material in the discharge from the abscess, to be followed by complete healing of the cavity. In other cases the pus infection renders the condition worse; the acute abscess, after incision, leaves behind a tuberculous cavity. As the result of the periglandular infiltration, the glands become matted together with firm, fibrous tissue, and these, with the infiltrated surrounding tissues, form firm, immovable, hard tumors,

sometimes of large size. In unfavorable cases all the stages of the disease may be found present in the same case—isolated glands, glandular conglomerates, abscesses, sinuses, tubercular ulcerations, scars, and areas of pus infection. When the glands soften and the rupture takes place into the deeper tissues, the infection may travel downward in the connective-tissue planes and come to the surface as a cold abscess above the clavicle, on the chest wall, or in the axilla.

It is only in rare cases that symptoms of compression of the trachea, esophagus, or of nerve trunks, with the production of neuralgias, attends tubercular glands of the neck, even though the masses are of large size. As a general rule, the diagnosis of tuberculous glands of the neck is easy. Simple inflammatory hyperplasia, as already indicated, is not of a progressive character. Malignant lymphoma tends to grow steadily larger; the individual glands are of larger size; periadenitis and abscesses are wanting; glands in other regions are usually soon involved. From cystic tumors, tubercular lymphoma can be differentiated by the use of an aspirating needle. In all cases of doubt the removal of a gland will usually aid in the diagnosis.

Syphilis of the Cervical Lymph Glands.—Syphilis of the cervical lymph glands may occur in all the stages of the disease. Since chancre is most common on the lips, tongue, tonsils, and face rather than on the skin of the neck, the glands in the upper part of the neck—submental and submaxillary—are usually involved. They coexist with the chancre, and are usually remarkably large and hard. In secondary syphilis the glands of the neck are uniformly enlarged. The superficial glands along the sterno-mastoid, at the base of the mastoid process and at the insertion of the trapezius, are usually palpable. The glands are hard and insensitive, movable, and vary in size from a pea to an almond. Other signs of syphilis are present. Quite rarely a gumma may form in the submaxillary region as a slowly growing, movable, painless tumor, which finally softens and ulcerates. The early diagnosis is often difficult, and depends largely upon the effects of iodid. I have recently seen a gumma beneath the sterno-mastoid which closely resembled a broken-down tubercular lymph node.

Under the title *Hodgkin's Disease* we have already discussed the diagnosis of *malignant lymphoma* or *pseudoleukemia*.

Primary Sarcoma of the Lymph Glands—Lympho-sarcoma.—There remains to be considered under primary affections of the lymph glands primary sarcoma of the lymph glands—lympho-sarcoma. The new growth begins in a lymph gland; the gland increases in size, and forms at first a soft, movable, rounded or oval tumor. On section it may differ in no particular from an ordinary hyperplastic lymph node. Microscopically the picture is that of a round-celled sarcoma, usually with a fine intercellular reticulum. In other cases combinations occur with spindle cells or other forms of sarcoma cells. *Clinically* the growth is characterized by a rather early perforation of the capsule and infiltration of the surrounding structures; a large tumor is rapidly formed, which

causes increasing pressure symptoms upon blood-vessels, nerves, esophagus, pharynx, and trachea. The skin is involved after a time; ulceration, the formation of fungoid growths, hemorrhage, infection, and sloughing of the tumor tissue are among the events of the later stages of the disease. The other lymph nodes usually remain unaffected, but secondary tumors often form in the vicinity, and may become fused with the parent tumor. The disease is rapidly fatal; life is rarely prolonged for more than a year or two from the appearance of the tumor. Death occurs from pressure on the trachea and esophagus, from hemorrhage, from invasion of the internal jugular with fatal thrombosis. Metastases may form in the lungs, etc., if the patient survives for a sufficient time.

Fig. 196. — Inoperable Sarcoma Originating in the Lymph Nodes of the Neck. (Bellevue Hospital, collection of Dr. L. W. Hotchkiss.)

Secondary Carcinomatous Infection of the Lymph Nodes of the Neck.—As already noted in many places in this book, secondary glandular tumors occur in the neck in cases of carcinoma of the lips, tongue, face, salivary glands, larynx, thyroid gland, esophagus, mammary gland, etc., the situation of the secondary glandular tumors depending upon the seat of the primary growth and the direction of the lymphatic current, less often in cases of sarcoma. The carcinomatous glands form hard, nodular masses, which soon become adherent to the surrounding parts. They often undergo degenerative changes, may soften, break down, and perforate the skin, forming ulcerating or fungating tumors. It is usually possible to find the primary tumor or the scar left by its removal. I recall but one case in which this was not the case. A man of thirty-five came to me with numerous discrete glandular tumors on both sides of his neck, affecting chiefly the groups of glands along the sheath of the vessels. One gland was removed, and was reported to be a typical carcinoma. No primary growth could be found, and since the patient withdrew himself from observation, I never knew the seat of the primary tumor. Since the above was written I have seen one similar case.

ANEURISMS OF THE NECK

Aneurisms of the Common Carotid Artery.—Aneurisms of the common carotid artery occur from wounds, punctures of the vessel, and gunshot wounds, which heal, but leave a weakened arterial wall; from subcutaneous injuries which bruise or tear the intima; from endarteritis proceeding from the ordinary causes—old age, alcoholism, syphilis, etc.; often from a combination of injury and disease. Carotid aneurism is rather more frequent in men than women. In Crisp's statistics of 551 aneurisms, 20 involved the innominate, 23 the subclavian, 25 the carotids. The common carotids are much more often affected than the external or internal. According to Barwell, in 87.35 per cent of the cases, 7 per cent affected the external, 5.75 per cent the internal carotid. Any part of the common carotid may be the seat of aneurism; the extremities more often than the middle part; the upper extremity more often than the lower. The *signs and symptoms* are pulsation and pain in the neck; later, the formation of a tumor, usually not very large, spindle-shaped or ovoid in contour, giving the signs of aneurism; sometimes enfeeblement or delay of the temporal pulse. Symptoms due to circulatory disturbances in the brain—headache, vertigo, sometimes attacks of syncope, disturbance of sleep. Pressure symptoms in the neck, notably paralysis of the recurrent laryngeal nerve, the cervical sympathetic, and hypoglossal. Disturbances of swallowing and breathing, of greater or less intensity, and, as stated, local pain. The anatomical situation of the tumor usually renders these aneurisms and their seat in the vessel easy to recognize; mistakes may, however, occur. If the sac is partly consolidated, pulsation may be feeble or wanting, and it may be taken for a glandular tumor or an abscess or blood cyst communicating with a vein. Pain and pressure symptoms, notably paralysis of the recurrent laryngeal nerve, strongly favors aneurism.

Aneurism of the External Carotid.—Aneurism of the external carotid is rare. A traumatic origin has been observed. The tumor forms behind the angle of the jaw beneath the sterno-mastoid, and causes a bulging in the pharynx. Pressure symptoms on the hypoglossal, glosso-pharyngeal, and spinal accessory nerves may be present, together with the signs of aneurism.

Aneurism of the Internal Carotid.—Aneurism of the internal carotid is exceedingly rare. The signs and symptoms are practically the same as those of the external carotid. Bulging in the pharynx may be marked at the site of the tonsil, and the aneurism may be mistaken for an abscess or a tumor in this region.

Aneurism of the Innominate Artery.—Aneurism of the innominate artery always arises from pathological changes in the vessel wall; since wounds of the innominate are always fatal, traumatic aneurisms do not occur. Any portion of the vessel may give origin to an aneurism. At its lower end the aorta may be included in the dilatation, at its upper end the right carotid, subclavian, or both. The aneurism may be either fusiform or sacculated, more commonly

the latter. As the aneurism increases in size, it may remain in the thorax, and the symptoms will consist at first in many instances of dyspnea. Examination may show dullness and a murmur or a thrill, or both, behind the sternum, or the X-rays may show a shadow on the fluoroscope or in a radiograph. If the tumor remains in the thorax, it will grow forward or backward, eroding the ribs and sternum, or the vertebræ, and causing pressure symptoms—dyspnea, dysphagia, etc. If the growth takes place upward, it will appear above the right sterno-clavicular joint and give the ordinary signs of aneurism. The clavicle may be eroded or its sternal end dislocated. The pressure symptoms on the trachea, esophagus, recurrent laryngeal nerve, brachial plexus, subclavian, and innominate veins give rise to dyspnea, dysphagia, partial paralysis of the larynx, neuralgias or palsies of the brachial plexus, edema of the arm, etc.; pressure symptoms of the heart and aorta and of the carotid and subclavian arteries, and even obliteration of the two latter in some cases, with cure of the aneurism, have been observed.

It is very easy to recognize the presence of the aneurism, not always so easy to tell whence it has arisen, since quite similar signs and symptoms may follow aneurism of the aorta, the innominate, the first portion of the carotid or subclavian. A simultaneous modification of both the radial and temporal pulse on that side would point to aneurism of the innominate. The history of the site at which the tumor first appeared, the transmission of the bruit, the direction in which the tumor grew, might aid in the diagnosis. Innominate aneurism usually ends fatally by internal rather than external rupture.

Aneurism of the Subclavian.—Aneurism of the subclavian is occasionally traumatic, resulting either from a punctured wound, or, in one or two instances, from blunt violence applied above the clavicle. In these latter cases death has been almost immediate, the artery having been ruptured with the formation of a rapidly increasing arterial hematoma. The spontaneous aneurisms of the subclavian do not differ in their causation from other spontaneous aneurisms, although it is believed that their occurrence might be determined by the existence of a cervical rib by pressure on the arterial wall. They occur in the first and third portions of the vessel. The aneurisms of the first portion are more common; they occur on the right side, more rarely in the intrathoracic portion of the left subclavian. Aneurism scarcely arises from the middle portion of the subclavian; this portion may, however, take part in the dilatation when the first or third part becomes the seat of aneurism. The signs and symptoms of aneurism of the first part of the artery are hardly to be distinguished from those of innominate aneurism. Aneurism of the third portion causes the appearance of a swelling in the supraclavicular region behind the clavicle, which gives the signs of aneurism. The radial pulse may be delayed or weakened; pressure upon the subclavian vein causes edema of the arm; pressure upward upon the brachial plexus causes neuralgias or paralysis of the muscles of the arm and forearm.

Aneurism of the Vertebral Artery.—The recorded cases of aneurism of the cervical portion of the vertebral artery have been traumatic, due to stab and gunshot wounds, usually of the back of the neck. The aneurism has in some cases developed as an arterial hematoma immediately after the injury, accompanied by the formation of a more or less diffuse, sometimes a circumscribed swelling in the region of the wound; pulsation and murmur have developed in certain cases. In a number of instances the signs of aneurism have developed slowly and not until many days after the injury. Pressure backward on the corresponding side of the front of the neck against the spine below the sixth cervical vertebra has usually stopped the pulsation in the tumor.

Arterio-venous Aneurism between the Common Carotid and the Internal Jugular Vein.—Arterio-venous aneurism between the common carotid and the internal jugular vein has, in a moderate number of reported cases, followed stab and gunshot wounds involving these vessels. The original wound has usually bled profusely, but the hemorrhage has been checked by clotting or pressure. Marked ecchymosis is usually present in the neck. The characteristic signs and symptoms develop in the course of from one to ten days, occasionally later. They are the thrill and murmur, continuous, but more marked during the systolic impulse. They are felt and heard by the patient, often to a distressing degree. If the communication between artery and vein is immediate (aneurismal varix) there may be no tumor felt, or a small tumor, circumscribed, rounded, or ovoid in shape. Pulsation may be expansile or not. The tumor is soft, and may be made to disappear entirely on pressure. If an intermediate sac forms between the vessels (varicose aneurism), the tumor may be of irregular shape and of considerable size. It will usually be firmer than in the former case, will diminish in size by pressure, but cannot be made to disappear. Pressure on the carotid lower down in the neck causes cessation of pulsation, thrill, and murmur in either case. The temporal pulse may be weaker on that side. There may be dilatation of the superficial veins of the face and neck. Cerebral symptoms may or may not be present, according to the extent of interference with the venous circulation in the interior of the skull. There may be headache, vertigo, confusion of mind. The continuous murmur may produce noises in the patient's head, such that he is unable to occupy his mind with work; sleep may be interfered with. These symptoms may be temporary and gradually pass away, or continuous, or grow progressively worse. The tumor may remain quiescent or, in the case of varicose aneurism, the sac may increase in size and expose the patient to the danger of rupture. Pressure on the recurrent laryngeal or pneumogastric may cause hoarseness, cough, etc.; generally speaking, the condition is far less threatening than is the case with ordinary aneurism. The question of operation is to be determined by the gravity of the symptoms in the individual case.

A very few cases of *arterio-venous aneurism of the external and internal carotid arteries have been observed.* From what has been stated, the diagnosis should be easy. *Arterio-venous aneurism of the subclavian artery and vein*

occurs, but is a rarity; simultaneous wounding of these vessels being usually a fatal injury. The signs and symptoms in the reported cases have been plain and characteristic.

TUMORS OF THE NECK

We have already discussed the tumors originating in the lymphatic glands. In regard to tumors of the neck in general, it may be said that they are frequent, of a very varied character, and originate in a great variety of structures. Their complex relations are important from a diagnostic and therapeutic point of view. Their evident attachment to certain structures frequently gives valuable diagnostic aid, and the symptoms produced, when they involve or press upon blood-vessels, nerves, larynx, esophagus, or trachea, often help to indicate their character and the probable dangers and difficulties of their removal, or to point to the probability that such removal will be either impracticable or useless. The details of these relations will be discussed as this chapter proceeds.

FIG. 197.—SARCOMA OF THE NECK, INOPERABLE. (New York Hospital, service of Dr. Stimson.)

The Diagnosis of Malignant Tumors of the Neck.—A word in regard to the diagnosis of malignant tumors of the neck. The mere question of malignancy is usually quite easy to determine; the question of operability is not so readily answered. A word of caution may not be out of place; a malignant tumor of the neck nearly always extends more widely and deeply into the tissues than an external examination would indicate. In addition to the mere anatomical difficulties to be met with—and they are often great, owing to the displacements of vessels and nerves—the bleeding is apt to be greatly in excess of what would be found when operating on a normal neck; and an inexperienced operator may find himself in a position whence he can neither go ahead nor easily retire from

a very difficult position. A malignant tumor of the neck which seems to be on the borderland of operability had better be let alone. In determining the question of operability, one is guided largely by the *mobility* of the tumor. A tumor which moves freely on the deeper structures is probably encapsulated, and may be easily removable, even though of large size. If firmly fixed to the vessels, the deeper muscles, the trachea, the esophagus, if symptoms of paralysis of the recurrent nerve, the sympathetic, or other deep nerve trunks, are present, it will indicate that these structures are pressed upon or infiltrated by the growth, and that difficulties and dangers will occur during the operation which the careful surgeon will anticipate and guard against as far as may be. Evidence that a malignant new growth of the neck is attached to the skull or to the cervical vertebræ, or that it extends below the level of the sternum, usually constitutes an absolute contraindication to removal, on the ground that such removal must necessarily be incomplete and without advantage to the patient.

In examining a tumor as to its mobility, it is to be remembered that the movement of the mass should be attempted in the line of the vessels or in the direction of the muscular fibers respectively. Motion may be apparently quite free, at right angles to the course of the vessel or muscle, and yet actually these structures are moving with the growth. In making such tests the muscle should be put upon the stretch if possible. Involvement of the trachea is indicated by dyspnea, by paralysis of the recurrent laryngeal nerve, by whistling breathing, and by the fact that the tumor cannot be moved upon the trachea. A character which distinguishes thyroid tumors from all others with which they might be confounded is that they move up and down with the larynx during the act of swallowing. After a tumor, thyroid or other, has pressed upon the trachea for some time, absorption or softening of the tracheal rings takes place. There may be dyspnea from flattening of the trachea; or the tumor may hold the trachea more or less completely open by adhesions. The moment such a tumor is removed from its tracheal attachments, the trachea will collapse with fatal results. The careful surgeon will anticipate this accident by tracheotomy, or be ready to introduce a tracheal cannula instantly if signs of imperfect breathing appear. Involvement of the esophagus is indicated by dysphagia.

Cystic Tumors of the Neck.—*Branchiogenic Cysts.*—Branchiogenic cysts arise from the persistence of some intermediate portion of the second branchial cleft or of the thyreo-glossal duct, the outer and inner terminations of these canals being closed. (See Congenital Fistulæ of the Neck.) The cysts arising from the second cleft occur on the side of the neck; those from the thyreo-glossal duct in the middle line. The cysts have a wall of more or less dense fibrous tissue, containing lymphoid tissue if the cyst arises from the inner embryonic layer. The cysts are lined with pavement epithelium or cylindrical ciliated epithelium; sometimes with a membrane containing all the structures of the skin. The cysts are usually unilocular, occasionally multilocular. Their contents varies; it may consist of clear serous fluid, of mucus, of oily material,

or of fatty material of solid or semisolid consistence, hair may be present, cholesterin crystals, etc.

The *cysts of the second cleft* occur between the hyoid bone and the sternum, usually along the anterior edge of the sterno-mastoid muscle. They are of very variable size, as large as a pigeon's egg, or, in time, they may develop into large tumors occupying much of the side of the neck. The superficial tissues are movable over them, but they have often quite firm, deep attachments to the sheath of the vessels, to the hyoid bone, and pharynx. They may appear at any time of life, most commonly from puberty to thirty years of age; they grow slowly; are neither painful nor sensitive, and are only unpleasant on account of deformity. They are smooth, elastic tumors, sometimes translucent, usually fluctuating, and have to be differentiated chiefly from cold abscess, rarely from lipoma, blood cysts, and cystic tumors of lymphatic origin. The introduction of an aspirating needle will usually decide the diagnosis. The contents of the branchiogenic cysts are as described. If they contain clear fluid, epithelial cells will be found in it.

FIG. 198. — BRANCHIOGENIC CYST OF THE NECK ARISING FROM THE SECOND CLEFT. (New York Hospital, service of Dr. Frank Hartley).

The *cysts arising from the thyreo-glossal duct* are usually small. They occur in the median line of the front of the neck just above or below the hyoid bone, or, more rarely, lower down as far as the sternum. They may be as large as a pigeon's egg, rarely larger than a hen's egg. They are usually attached to the hyoid bone. They are lined with flat or ciliated epithelium. Occasionally branchiogenic cysts undergo suppuration. They are also the seat of degenerative changes. Carcinoma may develop in the cyst wall, also proliferating adenoma, together with combinations of adenoma and lymphangioma.

Congenital Cystic Hygroma of the Neck—Congenital Cystic Lymphangioma.—The tumor consists of dilated lymph vessels and spaces lined with endothelium. The walls of the cavities consist usually of a very thin and delicate fibrous tissue. The contents of the dilated lymph spaces consist of clear or slightly milky, watery fluid, sometimes having a pale brownish tinge. The size of the individual cavities varies from minute spaces to those as large as a good-sized plum. The several cavities may or may not communicate with one another. These tumors vary greatly in size; at birth they may be so small

as not to be noticed, or they may occupy a large part of the side of the neck and be as large as an orange, even in a small infant. They most commonly are situated in the upper part of the neck in front of or behind the sterno-mastoid muscle, but may occur in any part of the neck. They may have their origin in the subcutaneous connective tissue, or in the deeper structures of the neck—the sheath of the vessels, for example. They are smooth elastic tumors, but not compressible, and may thus be distinguished from cavernous angioma. They possess a peculiar tendency to grow and spread insidiously along the connective-tissue planes. The trabeculated or cystic lymphatic tissue gradually forces its way between the trachea and œsophagus, surrounds the vessels, invades the intermuscular planes of the deep muscles, etc. The dangers and difficulties of operative removal of these tumors may therefore be very great. They may extend downward into the supraclavicular fossa or into the axilla or mediastinum. Attacks of inflammation may occur in the walls of the various cavities, sometimes leading to obliteration and cure of portions of the tumor. The prognosis is, in general, not very favorable.

Blood Cyst of the Neck.—A cystic tumor containing fluid venous blood may occur in the neck from a diverticulum of a large vein, from hemorrhage into some form of cystic tumor—branchiogenic cyst, lymphangioma, or be developed in a cavernous angioma. These tumors show, on aspiration, a content composed of venous blood. They do not pulsate. If they communicate with a vein, they are reducible; if of other origin, they are not. They are sometimes congenital tumors, but may arise, if proper antecedent conditions exist, at any time. They may be large or small. They occur usually beneath the border of the sterno-mastoid at any level. They form smooth, rounded, fluctuating swellings, covered by normal skin and fairly movable. They grow to a certain size, and remain stationary, or continue to grow and spread, even as far as the axilla. The diagnosis of a cystic tumor containing blood is easy. The differential diagnosis as to its origin must depend upon the anatomical conditions found at operation. If the cyst communicates with a large vein—internal jugular or subclavian—it will be increased in size and tension by coughing, straining, crying, etc.

Subcutaneous Atheromatous Cysts of the Neck.—Subcutaneous atheromatous cysts of the neck occur in any part of the neck. They are characterized here, as elsewhere, by their slow growth. They are elastic, rounded, smooth swellings, movable on the parts beneath, but adherent at one point to the skin. They often become infected and suppurate.

Cysts of the Mucous Bursæ of the Neck.—These occur in the vicinity of the hyoid bone. They form small and harmless cystic tumors in the middle line of the neck, just above, or more often just below, the hyoid bone, or on the anterior surface of the thyroid cartilage. They are firmly attached to the hyoid bone or thyroid cartilage, and move with the larynx. They contain clear fluid. These cysts seldom attain a size larger than a pigeon's egg, and usually give no symptoms unless they become infected, or inflamed by mechan-

ical irritation. A differential diagnosis between these and cysts of the thyreoglossal duct is only possible by a microscopic examination of the cyst wall. The same is true of cysts of accessory thyroids in this situation and of cysts of the so-called suprahyoid gland (Zuckerkandl).

Echinococcus Cyst of the Neck.—The neck is a rare localization for this disease. The cyst forms, as a rule, in the deeper tissues of the neck, often near the sheath of the vessels, and grows outward toward the surface, forming a tumor which presents in front of or behind the sterno-mastoid or raises this muscle from its bed and forms a tumor which projects to the front and rear. A characteristic of these cysts is an intermittent growth. The sudden accessions in the size of the tumor are attended by pain, tenderness, and other signs of inflammation. The diagnosis may be aided by the presence of a cystic tumor, elastic and fluctuating, which shows the characteristic thrill or vibratory sensation transmitted to the hand when the tumor is sharply tapped, although this sign is said to be rarely present in the neck. The surface may be rounded and smooth or more or less uneven from the multilocular character of the cyst. The use of the aspirating needle will show the presence of clear fluid containing the hooklets of the worm. (See Echinococcus.) In the neck, as elsewhere, echinococcus may become infected and suppurate. Although these cysts usually grow slowly and intermittently, in time they may reach a large size and cause serious pressure symptoms, even obliteration or erosion of important vessels; in the latter event with fatal bleeding, as has happened in several cases. If they extend downward, pressure on the brachial plexus will cause neuralgias, palsies, etc.

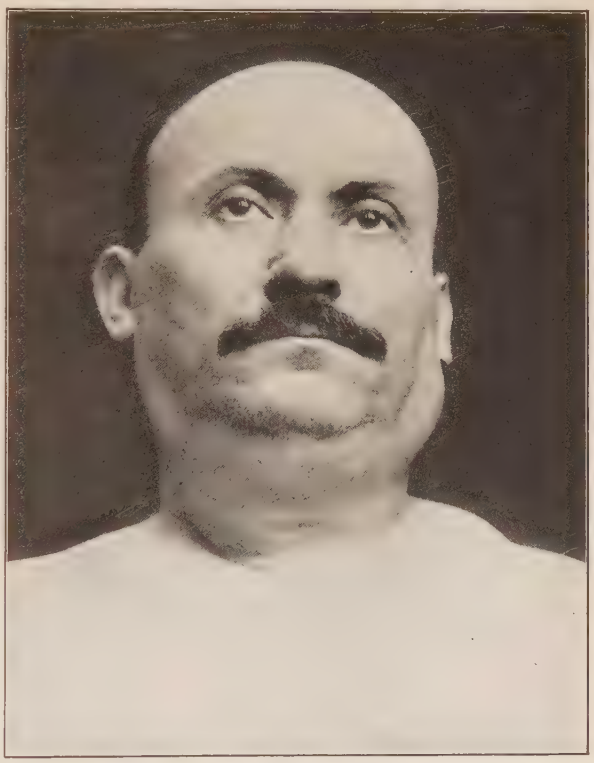


Fig. 199.—Multiple Lipomata of the Neck. (Author's case.)

Angiomata of the Neck.—*Angioma simplex* (*nevus vasculosus*) occurs upon the neck in various situations, either in the skin or subcutaneously, and is to be recognized here as elsewhere. (See Tumors.) *Angioma cavernosum* occurs in the neck as a con-

geries of dilated veins and spaces filled with venous blood. When superficial the recognition is easy. (See Tumors.) When deeply placed the diagnosis is scarcely possible, since the characteristic signs are wanting, until the growth approaches the surface.

Cavernous Lymphangioma.—Cavernous lymphangioma has also been observed a very few times in the neck. In the reported cases the tumor was in the supraclavicular triangle and formed a soft compressible mass, which could hardly be differentiated from a deep-seated lipoma or a cavernous angioma.

Solid Tumors of the Neck (*Lipoma*).—Lipoma occurs in the neck in both the circumscribed and diffuse forms. The circumscribed lipomata occur especially at the back of the neck, where they form sessile or pedunculated tumors of varying size. Some of these tumors in time grow to be very large. In the front of the neck they may be superficial or of rather deep origin, so that they raise the sterno-mastoid, and project in front or behind the muscle; such a case is shown in the illustrations. While the diagnosis of the superficial forms is simple, here as elsewhere (see Tumors), the deep-seated lipomata may readily be mistaken for other forms of new growth. Diffuse lipoma of the neck occurs almost exclusively in men of middle age. The neck is surrounded by rounded or more flat diffuse masses of fatty tissue producing marked deformity and much annoyance on account of the mere size of the tumors. Pressure symptoms are rare (see illustration).

Fig. 200.—Superficial Lipoma of the Neck. (Author's case.)

Fibroma of the Neck.—Fibroma molluscum, large and diffuse, or small and circumscribed, sessile or pedunculated, occurs upon the neck in various situations; its recognition is easy. They are sometimes combined with plexiform neurofibroma. (See Fibroma.) More deeply placed fibroma, arising for the most part from fascial planes, occurs notably in the back of the neck; the tumors are slowly growing, firm masses of fibrous tissue. In the side of

the neck they usually arise from the connective-tissue sheaths of vessels and nerves, and are present beneath the sterno-mastoid. In the front of the neck they are exceedingly rare. The diagnosis of these fibrous tumors is not difficult; they are too firm in consistence for lipoma; they grow too slowly to be sarcomata, and the infiltration and widespread adhesions of malignant growths are wanting.

Chondroma and Osteoma.—Chondroma and osteoma are occasionally observed in the lower part of the neck, arising from the cervical vertebræ, the first rib, or the clavicle. They are hard, immovable tumors of slow growth, attached to bone. They may give rise to pressure symptoms. The diagnosis of osteoma might be aided by an X-ray picture.

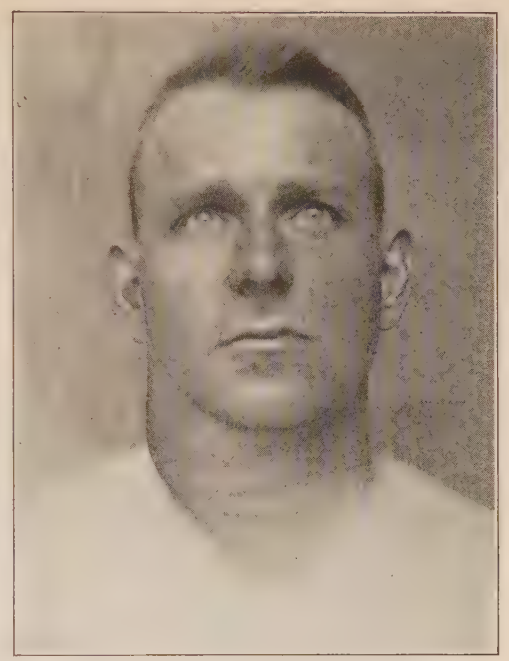


FIG. 201.—LIPOMA OF THE NECK DEEPLY PLACED BENEATH THE STERNOMASTOID MUSCLE, AN UNUSUAL SITUATION. (Collection of Dr. Charles McBurney, Roosevelt Hospital.)

FIG. 202.—LIPOMA OF THE SUPRACLAVICULAR REGION. (Collection of Dr. Charles McBurney.)

Neuroma.—Isolated neurofibroma may occur in the superficial or deep nerves of the neck, and form quite large tumors, giving rise to symptoms of paralysis or irritation. *Plexiform neuroma* is more common, and may affect superficial or deep nerves. The superficial form has already been spoken of elsewhere. The peculiar appearances of thickening of the skin, pigmentation, and the soft, cordlike masses beneath the skin are characteristic. In the deep form the diagnosis is not likely to be made until operation is undertaken. I once assisted Dr. Robert Abbe at an operation upon a case of this kind. The patient was a little girl, and the large, partly nodular and firm, partly cordlike and soft masses formed a con-

siderable tumor in the neck beneath the sterno-mastoid muscle and behind the vessels, extending from the hyoid bone to the clavicle and below it. The growth originated in the cervical sympathetic.

Sarcoma of the Neck.—*Lympho-sarcoma* of the neck has already been described. The skin (*pigmented moles*), the muscles, bones, and connective-tissue planes of the neck may all be the starting point of sarcoma of various types. These tumors are characterized here as elsewhere by all the signs and symptoms peculiar to malignant new growths, already sufficiently described under Tumors.

Carcinoma of the Neck.—Carcinoma of the neck occurs superficially as *epithelioma*, the characters of which have been sufficiently described under Tumors. Epithelioma of the neck is very rare as compared with similar new growths upon the face. Cancer may also occur as deep-seated carcinoma having an origin other than in the skin; these latter arise in a variety of situations, notably from carcinomatous degeneration in the walls of branchiogenic cysts, further in accessory thyroid glands. These tumors are not numerous, comparatively few cases having been observed. They have all occurred in elderly men. The tumor has been situated in the majority of the cases in the upper part of the neck, and has presented as a hard nodule beneath the sterno-mastoid muscle. The growth has been rapid, attended by marked pain, by early infiltration of the surrounding structures, notably early adhesion to the sterno-mastoid, early infection, enlargement and induration of the neighboring lymphatic glands, by adhesion to and perforation of the skin, ulceration, hemorrhage, and the rest of the dismal story common to cancers. The early diagnosis of these carcinomata, except by operative removal, is not likely to be made. Nodular tumors in this vicinity, such as lymphomata, tubercular or other, are very common, while this form of carcinoma is exceedingly rare.

FIG. 203.—MALIGNANT TYPE OF EPITHELIOMA OF THE NECK, IN A YOUNG MAN AGED TWENTY-SIX. (Author's case.)

DISEASES AND TUMORS OF THE THYROID GLAND

Exophthalmic Goiter (*Graves's Disease — Basedow's Disease*). — The pathology of Graves's disease is not certainly known. A theory which has met with rather wide acceptance is that the symptoms are due to a toxemia caused by the absorption of an increased or altered secretion from the thyroid gland. The *signs* and *symptoms* of the disease are: (1) Enlargement of the thyroid gland. (2) Protrusion of the eyeballs. (3) Tachycardia (an increased rapidity in the pulse rate). (4) Other associated symptoms, constant and inconstant. The disease is much more frequent in women than men. The patients are often neurotic or hysterical individuals. Anemia, hemorrhage, and other depressing conditions appear sometimes to act as predisposing causes, as do profound emotional disturbances.

1. The enlargement of the thyroid may be marked or moderate, and is usually symmetrical. Its consistence is soft or of medium firmness. The size is rarely great enough to produce pressure symptoms.

2. Exophthalmos may be marked, moderate, or, rarely, absent. There is an increase in the size of the space between the lids; when the patient is directed to look downward, the upper lid in its motion lags behind the eyeball. There is absence of the power to converge the axes of the two eyes—i. e., the patient cannot look at the end of her nose with both eyes at once; when directed to do so, the eyes turn to the right or to the left, but only one eye turns toward the middle line. The patient winks less often than normal.

Fig. 204.—Exophthalmic Goiter. (Case of Dr. William Downs.)

3. The action of the heart is rapid—120–140 beats a minute or more. Palpitation and tumultuous action of the heart occur from slight mental or physical disturbances. Attacks of angina pectoris occur in bad cases associated with myocarditis.

4. Diarrhea of a serious and even fatal character may occur. *Nervous symptoms.*—A constant symptom is muscular tremor, not unlike that of chronic alcoholism, most marked in the hands, but also involving the muscles of the trunk. Choreic movements may be present. Hysterical attacks are common, as are nervous irritability and other symptoms of neurasthenia. To be mentioned also are increased secretion of sweat, vasomotor disturbances, flushing,

edema, pigmentation. The patients often become anemic, suffer from muscular weakness and emaciation. The disease is fatal in a considerable proportion of those cases which run an acute course, chiefly from conditions referable to degeneration of the heart muscle. In other cases diarrhea constitutes a serious menace to life. It is to be borne in mind that any one of the characteristic symptoms of the disease may be absent; further, that other varieties of goiter and cysts and tumors of the thyroid gland may be associated with the symptoms of exophthalmic goiter.

Cretinism, Myxedema, and Cachexia Strumipriva.—In certain localities, where, owing, apparently, to some quality in the water supply, diseases of the thyroid gland are endemic and frequent, children are born, apparently normal at birth, who do not develop normally either in stature or intelligence. They are dwarfs; the special senses are blunted; they are often deaf; they may never learn to speak; they suffer from peculiar nutritive disturbances of the skin and its appendages. In such cases the thyroid gland is found to be atrophied or nearly absent, in some cases enlarged but functionless. These unfortunates are known as "cretins"; they are practically idiots. The condition is not a surgical one, and therefore is not described at length.

Myxedema is a corresponding condition occurring in adults who suffer from atrophy of the thyroid gland, and *cachexia strumipriva* is an analogous condition which follows the total operative removal of the thyroid, rarely tumors and disease of that organ. A few words in regard to this condition may not be out of place. In a certain number of cases the removal of the thyroid has been followed in hours or after a few days by tetanic spasms of the voluntary muscles, first of the upper extremities, then of the lower, spreading to the neck and trunk, finally to the diaphragm, and ending in death in a large proportion of cases. The tetanic contractions occur in attacks of variable duration, and in the fatal cases after diminishing intervals. As *a means of early diagnosis* may be mentioned Trousseau's phenomenon—namely, if a large blood-vessel or nerve trunk be compressed in an extremity for a minute tetanic spasms of the muscles are produced; further, a tap or light stroke in front of the ear causes sudden violent contraction of the muscles supplied by the facial nerve of that side.

In other cases death does not occur, and the condition goes on to assume a chronic form, about to be described, known as cachexia strumipriva. The lamentable state may follow immediately the removal of the thyroid, usually it is gradually developed after weeks or months; the symptoms are essentially the same as those of myxedema. Milder forms may follow partial removals of the thyroid. After a period of health of variable duration following removal of the thyroid, the individual gradually passes into a state of mental apathy, loses all interest in life. There is a gradual abolition of physical and mental energy; the temperature of the body is subjectively and objectively lowered. There is edematous thickening of the skin. The skin of the face becomes swollen, thickened, and waxy in color. There is cessation of secre-

tion in the sweat and sebaceous glands. The face loses all liveliness of expression; the patient looks dull and stupid. The edema differs from ordinary serous infiltration in that the tissues do not pit on pressure. The hair falls, often completely. The swollen dry condition of the skin extends to the trunk and extremities. There is often marked edematous swelling in the supraclavicular region. The mucous membrane of the mouth and throat is often swollen, so that speech is interfered with. There is diminished cutaneous sensibility. There is usually anemia, diminution in the number of red cells and of hemoglobin of a moderate degree, and slight leucocytosis. The sexual organs undergo atrophy or cease to functionate. The mental condition gradually grows worse until the patients are in a condition of stupor from which they can scarcely be roused. In young persons the symptoms are most marked and acute in their course. The growth of the bones in length is interfered with. Untreated, these cases end fatally after an interval which may extend over a period of years.

Acute Inflammation of the Thyroid Gland.—Either the normal gland, or more often a gland the seat of one or other of the forms of goiter, may become inflamed as the result of an infected wound; further, as a metastatic process in the course of any of the acute infectious diseases—typhoid, pyemia, septicemia, the exanthemata, diphtheria, erysipelas, and acute inflammations of the alimentary canal. The *symptoms* are those of localized pus infection and more or less marked sepsis. Local pain, tenderness, and swelling, followed by redness of the skin and fluctuation if an abscess makes its way to the surface. Such an abscess may burst into the trachea or esophagus, or burrow downward into the mediastinum. Incision may permit the escape of pus or of a more or less extensive slough of the gland tissue. Pressure symptoms, dyspnea, etc., are not uncommon.

Syphilis.—The thyroid may be swollen during the early months of syphilis. The enlargement is transitory and not marked. Gumma of the thyroid occurs as a nodular or more diffuse and sometimes rather rapidly growing hard tumor of the gland accompanied by a good deal of pain and by pressure symptoms, dyspnea, and symptoms of pressure on the recurrent laryngeal nerve. The diagnosis of a malignant growth can only be excluded by the use of iodid, or by the presence of other evidences of syphilis.

Tubercular Inflammation of the Thyroid Gland.—Miliary tubercles may be present in the gland during acute general miliary tuberculosis. Circumscribed or diffuse areas of tubercular infiltration may occur as a localized process in the gland. I have seen one such case. One half the thyroid was involved and was swollen, hard, and nodular. Operation disclosed areas of caseation of considerable size, and submiliary and larger tubercles scattered throughout the substance of the gland. The patient was a young woman who showed other evidences of tuberculosis, as has been regularly observed in these cases.

Echinococcus of the Thyroid.—Echinococcus of the thyroid has been observed. There are no positively distinctive diagnostic features other than have

been spoken of under Echinococcus. Fatal perforation into the trachea has taken place in a number of cases, and that before the cysts had reached a very large size.

Bronchocele. Goiter.—Benign enlargements of the thyroid gland, whether they involve the whole or only a part of the gland, are known by the general name of goiter. If the enlargement is malignant (carcinoma-sarcoma), that adjective is prefixed. Although the pathology of the thyroid is rather complicated, it appears necessary to speak of it at some length, for a recognition of the character of the various lesions has an important bearing on the surgical treatment. The enlargement of the gland may be diffuse or partial. The diffuse hypertrophies may involve the parenchyma, the stroma, or the blood-vessels, or all three. In the last case the gland is simply increased in size, the relative proportion of the structures of which it is composed remains normal (parenchymatous goiter), or the contents of the glandular follicles are increased in quantity (follicular diffuse goiter). The contents of the gland follicles may undergo colloid degeneration, and the process may be accompanied by the fusion of several follicles into one larger space (diffuse colloid goiter). Less commonly the fibrous stroma of the gland is increased in amount at the expense of the glandular elements. The gland becomes hard and nodular, and often diminished in size. When, along with an increase in the glandular elements, arteries or veins or both are notably increased in size, we sometimes speak of a "*vascular goiter.*"

Partial Hypertrophies.—The changes are the same as in the diffuse forms, but are limited to a circumscribed portion of the gland. In these areas of hyperplasia, cysts may be formed either by absorption of the walls of contiguous follicles, or from hemorrhages, or from necrosis of a limited area of tissue. The cysts may be single or multiple, close together, or scattered throughout one or both lobes of the gland. They vary in size from that of a pea to an orange or larger. In the first variety the wall of the cyst is at first thin and delicate; later it may become thickened and fibrous. Calcareous degeneration may take place in the cyst wall; rarely thin, bony plates may be developed. So long as the interior of the cyst is lined with epithelium, the contents of the cyst may increase in quantity and the cyst increase in size. The contents of the cysts may be colloid material, the consistence of which may be thin and watery, or semifluid and viscid, or soft solid, and may contain cholesterin crystals. If, as often happens, bleeding occurs into the interior of the cysts, the color and consistence will be thin, brown, and turbid, or thick, pasty, and chocolate-colored, etc., according to the amount of blood and colloid material respectively. In those cysts which arise primarily from hemorrhage into the substance of the gland, the contents are often brown, pasty material, or in some cases lime salts are deposited in the ancient blood clot to a variable extent, producing dry, puttylike masses, or hard calcareous nodules. The place of such blood clots may be taken by firm fibrous tissue forming fibrous nodules in the gland. The connective-tissue stroma of the hyperplastic portion of gland sub-

stance may undergo hyaline degeneration. Any or all of these changes may go on at once in separated areas of the gland, or in adjacent areas. There occur, further, circumscribed nodular tumors of the thyroid, either congenital or developed first at puberty, the tissue of which departs from the normal in that it preserves the fetal type of gland tissue (Wölfler's fetal ade-

Fig. 205.—Parenchymatous Goiter. (Author's case.)

Fig. 206.—Parenchymatous Goiter. (Collection of Dr. Charles McBurney.)

noma). Also tubular adenomata, preserving the fetal type of tissue, and tubular adenomata, in which the tubules are lined with cylindrical epithelium. These constitute the benign forms of goiter.

Accessory Thyroids.—Portions of thyroid tissue may occur in various situations, either connected with the thyroid gland by a bridge of fibrous tissue or as independent masses. In the former case their relation to the thyroid is in most instances easy to recognize. They move with the thyroid and trachea during the act of swallowing, or their connection can be demonstrated on manipulation. In the latter case the diagnosis is often impossible. Accessory thyroids were classified by Madelung into inferior, posterior, superior, and anterior accessory thyroids. The inferior group may be substernal, intrathoracic, or retroclavicular. The retrosternal are the most frequent; they are usually connected with the thyroid isthmus by a band of fibrous tissue. The posterior occur between the esophagus and vertebræ, and may give rise to difficulty in swallowing. The superior may occur above the hyoid bone or at the base of the tongue. The anterior accessory thyroids are exceedingly rare; the term has been used to designate the rare cases in which an accessory thyroid connected with the thyroid isthmus has descended under the skin of the thorax in front of the sternum instead of assuming a retrosternal situation, as is commonly the case.

Symptoms.—The symptoms produced by enlargements of the thyroid depend upon the size and situation of the tumor and the rapidity of its growth, and are chiefly due to pressure upon surrounding organs—trachea, œsophagus, blood-vessels, and nerves. Respiratory symptoms may be slight or marked. If the tumor is considerable in size, dyspnea on exertion will be complained of, accompanied by whistling breathing; there may also be attacks of severe dyspnea, which come on without warning and may awaken the patient out of his sleep. Such attacks may be alarming, or even fatal. They may be due to compression of the trachea or to pressure upon the nerves of the larynx. The recurrent laryngeal may be compressed upon one or both sides. If one nerve is paralyzed, one vocal cord cannot be abducted. Disturbance of voice and dyspnea are the result. If both, such dyspnea may be fatal. These patients suffer from aphonia. The retrosternal thyroid tumors, and those which surround the trachea, are especially liable to cause such symptoms. The compression of the trachea by tumors of the thyroid is of several types. If the tumor surrounds the trachea the compression may be circular; the caliber of the trachea in the compressed area is symmetrically diminished. Lateral compression is more common from one or both sides. If the pressure is unilateral, the trachea may be narrowed from side to side and sharply bent; a perilous condition, attended by the danger of sudden collapse of the trachea and death from asphyxia. Bilateral compression may cause the trachea to be narrowed to a mere slit, broader in front than behind; in this condition the trachea has been likened to the scabbard of a saber. Intrathoracic goiters, either in front of the trachea or behind the œsophagus, may compress the trachea against the vertebræ or the sternum, respectively. It is to be remembered that all these forms of compression, if prolonged, are attended by softening and absorption of the cartilaginous tracheal rings. Irritation of the recurrent nerves may cause spasm of the larynx, with spasmodic cough, hoarseness, and dangerous dyspnea. Pressure upon the cervical sympathetic will cause irritation or paralysis of that nerve trunk, with corresponding symptoms (see Injuries of the Cervical Sympathetic). Pressure symptoms upon the main trunk of the pneumogastric are rare except from tumors which surround the trachea or lie behind the œsophagus, and in malignant tumors of the thyroid. The most notable symptoms of irritation of the pneumogastric is tachycardia. Pressure upon the lower cervical nerves may cause neuralgic pain in the arm. Pressure symptoms on the gullet are confined to those thyroid nodules which grow backward chiefly upon the left side, to circular goiters surrounding the trachea, and to accessory thyroids behind the œsophagus and to malignant tumors. The symptoms are rarely urgent. There may be pain in swallowing, but there is rarely difficulty in swallowing solid food. Although the thyroid arteries are often notably increased both in length and caliber in the presence of large goiters, no symptoms other than increased pulsation are ordinarily produced. The carotids are displaced backward and outward as the tumor grows, and may often be felt and seen pulsating behind the sterno-mastoid muscle, sometimes quite su-

perficially. Pressure upon the veins causes congestion, often cyanosis of the face, by obstruction to venous return, notably in goiter occupying the superior aperture of the thorax. The cyanosis is most marked after muscular effort. While the patient is quiet the face is often notably pale. In some cases there may be edema of the arm and swelling of the mucous membrane of the mouth. There is often dilatation of the right side of the heart (tachycardia and palpitation). The superficial and deep veins of the neck are often dilated.

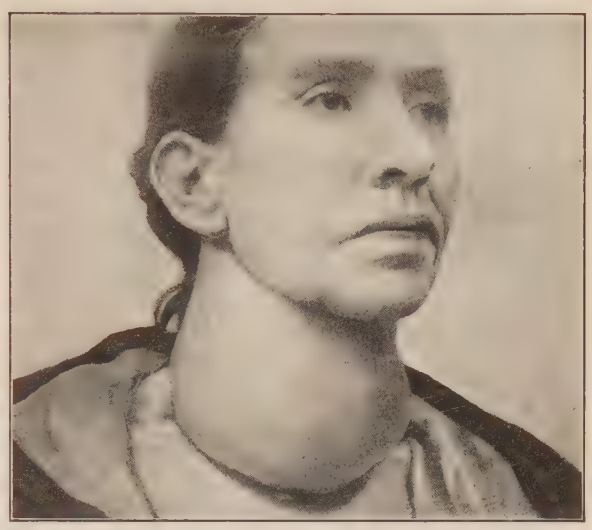


Fig. 207.—Cystic Goiter of Rather Large Size. Circumference of the neck 17¾ inches. (Collection of Dr. Charles McBurney.)

Differential Diagnosis of Goiter.—The mere enlargement of a normally placed thyroid gland, whether diffuse or circumscribed, is easily recognized. The anatomical situation of the tumor and the fact that it moves up and down with the larynx during the act of swallowing is enough to connect it with the thyroid gland. Inspection of the individual and of the neck gives much information. If the enlargement is symmetrical and is associated with exophthalmos, the diagnosis of exophthalmic goiter needs only a brief inquiry into the subjective symptoms and history to render it certain. We are further able to note the size and situation of the tumor, whether it affects one or both lobes or the isthmus. Pressure on the veins is indicated by cyanosis or congestion of the face and dilated subcutaneous veins. Paralysis of the sympathetic is indicated by a contracted pupil, partial ptosis, flushing of the affected side of the face, etc. Irritation causes a dilated pupil, sometimes exophthalmos, paleness of the skin, etc. By palpation we determine the mobility of the tumor. Unless a thyroid is very large or is wedged into the superior aperture of the thorax, or is one of the rare congenital forms which surrounds the trachea, it is usually quite movable. Immobility suggests malignancy. Adhesion of the skin to the tumor indicates malignancy or inflammation. The consistence is best tested by palpation with both hands. The presence of cysts, of hard, fibrous nodules, may be thus detected. The position of the larynx and trachea, whether displaced, bent, or compressed, may be determined more or less accurately in the same manner. By auscultation, whistling or harsh breathing may be heard, indicating compression of the trachea or involvement of the nerves of the larynx. In some very vascular goiters a soft systolic murmur may be present over the tumor.

Laryngoscopic Examination.—If one or both recurrent nerves are pressed upon, or unduly stretched by the tumor, the laryngoscopic picture may show one or both vocal cords paralyzed so that they cannot be abducted. In some cases displacement or narrowing of the trachea may be recognizable through laryngoscopic examination. The presence of a thyroid tumor being established, it is desirable to determine its character. In the United States, diffuse hyperplasias of the thyroid are less common than in those countries—portions of Switzerland, certain counties in England, and districts in India—where goiter is endemic. By far the largest proportion of cases seen in America are circumscribed tumors of one or other lateral lobe, and of these the cystic variety is notably frequent.

Simple Hyperemia of the Thyroid.—Simple hyperemia of the thyroid occurs for the most part in young women and girls; is associated with puberty, menstruation, or pregnancy. The gland is moderately enlarged, not sufficiently to cause marked deformity, of soft and normal consistence. In some cases this condition precedes permanent follicular hypertrophy of the gland of the diffuse type. The individuals thus affected are usually young women. The entire gland is markedly increased in size and of firm consistence. The surface may be smooth, or here and there groups of follicles may cause rounded elevations of small size on the surface. One or more soft nodular prominences appearing at the time of puberty in a gland otherwise normal, which grow very slowly or remain stationary and do not reach a size larger than a small hen's egg, and cause no symptoms other than slight deformity, are often fetal adenomata (Wölfler's).

Fig. 208.—Cystic Goiter.
(Collection of Dr. Charles McBurney.)

Colloid Goiter.—Colloid goiter of the diffuse type occurs for the most part in women during middle life. The tumor is of slow growth, but attains, after a time, a large size. The two halves of the gland are usually enlarged unequally. They may form prominent tumors, each as large as a

man's fist or larger. The consistence is rather soft and doughy. When diffuse hypertrophy affects especially the blood-vessels, the entire gland is enlarged, and may pulsate distinctly on palpation. There may be a vascular murmur. The tumor can be diminished in size by firm compression, but enlarges again rapidly as the blood reënters the vessels.

Fibrous Goiter.—Fibrous goiter is a comparatively rare form. It occurs for the most part in persons advanced in life, and is characterized by the formation of nodules of dense, hard, fibrous tissue disseminated through the substance of the gland. The individual nodules may be as small as a pea or occupy an entire lateral lobe and form a mass of considerable size. Calcareous degeneration in the nodules renders them as hard as bullets. The nodules are usually movable one on the other. They may project from the surface of the gland and become pedunculated.

Fig. 209.—Cystic Goiter.
(Collection of Dr. Charles McBurney.)

Cystic Thyroid.—The formation of cysts has already been described. They may form in a gland apparently otherwise normal (a very common form in the United States), or in combination with diffuse hypertrophy of the parenchymatous or fibrous variety. The cysts vary greatly in size, from that of a pea to an orange; in some cases they reach an enormous size, and cysts have been removed weighing many pounds. They may be single or multiple. The diagnosis is easy if the cyst is of fair size and not too deeply placed. They form rounded, smooth, elastic, fluctuating prominences. If large, superficial, and filled with clear fluid, they may rarely be translucent. If small and deeply placed in the gland, and especially if a calcareous deposit has taken place in the cyst wall, the diagnosis may be difficult. The diagnosis may be confirmed and the character of the contents of the cyst may be determined with an aspirating needle. In introducing a needle into the thyroid for diagnostic purposes, the strictest precautions of asepsis should be observed. The needle should be fine. The danger of wounding one of the enlarged and thin-walled veins of a thyroid tumor with a large aspirating needle and the subsequent formation of an annoying or even serious hematoma is not remote. *Unless the surgeon is prepared to operate at once, it is better to omit the use of a needle altogether.* The diagnosis of accessory thyroid tumors is often impossible. If

the tumor is still connected with the thyroid by a pedicle of thyroid or fibrous tissue, it may not be difficult. The presence of enlargement, diffuse or circumscribed, in the gland itself might be an aid, as well as a history of prolonged sojourn in a goitrous district. Tumors in the suprahyoid region and in the base of the tongue may be accessory thyroids. The thyroid may surround the trachea as a congenital condition. The tumor may cause obstructive symptoms of a serious or fatal character soon after birth, or if the thyroid becomes enlarged, at any subsequent time. "Movable thyroid tumors" are wholly or partly detached portions of thyroid tissue which lie in front of the trachea and move in and out of the superior orifice of the thorax, descending with inspiration, rising with expiration. If they become swollen, inflamed, or calcareous, and thus impacted behind the sternum, they give rise to serious pressure symptoms upon the trachea and innominate vein.

Malignant Tumors of the Thyroid.—Both sarcoma and carcinoma occur in the thyroid gland with moderate frequency, notably in goitrous regions and in thyroids already the seat of benign enlargements.

Sarcoma.—Any of the types of sarcoma may occur in the thyroid. Usually the tumor involves one lateral lobe; less commonly the entire gland is infiltrated. The sarcomata are characterized by rapid growth, rather early perforation of the gland capsule and infiltration of the surrounding tissue, and serious pressure symptoms often the ultimate cause of death. Symptoms referable to pressure upon the esophagus are more frequent and more marked than is the case with benign growths, serious obstruction of the esophagus being common from malignant infiltration or pressure, rare from the pressure of a benign growth. The skin is rather rarely involved and destroyed with ulceration, hemorrhage, necrosis, putrid decomposition, etc. The disease usually occurs in early adult life. So long as the capsule remains intact the tumor is movable. After the surrounding tissues are invaded, more or less fixation occurs. The consistence varies with the type of sarcoma, but is usually rather soft than hard. Metastases occur, notably in the lungs and bones.

Carcinoma of the Thyroid.—Carcinoma occurs in the majority of cases in advanced life, but has been observed in young persons. Ordinary alveolar carcinoma of the soft medullary and rapidly progressive type is the rule. Scirrhus also occurs, but is much more rare. A third type, commonly known as adeno-carcinoma of the thyroid, occurs in only a few cases, and is a very interesting tumor, since, although it cause metastases, it does not infect the lymph glands, and in most instances neither the thyroid itself nor the secondary tumors depart in histological structure from the normal gland tissue. The thyroid may even remain normal in size and yet metastatic tumors form, which recur after removal. The secondary tumors occur very commonly in the bones. The metastatic tumors are sometimes solitary. They occur notably in the skull and lower jaw, in the clavicle, ribs, and other long bones. The growth may be very slow, so that years elapse before the tumor reaches a considerable size. Strangely enough, the secondary tumors may show the structure of alveolar

carcinoma, and alveolar carcinoma of the thyroid may produce metastases resembling in structure the normal thyroid. Clinically the metastases in the bones resemble sarcomata. The alveolar carcinomata of the thyroid occur more often, as stated, in advanced life and in goitrous thyroids rather than in young persons with normal glands. The tumor usually begins as a nodule, which grows rather rapidly and may infiltrate the entire gland; perforates the capsule and infiltrates the surrounding tissues; causes infection of lymph nodes and metastases. These tumors ordinarily cause early and grave pressure. Symptoms are pain, dyspnea, dysphagia, recurrent laryngeal and sympathetic paralysis, pressure upon the veins with congestion, edema, etc.; but it is astonishing to what a large size a carcinoma of the thyroid may attain and yet leave the patient fairly comfortable, notably, if while the tumor grows a fibrous capsule continues to surround it at least in part. I recall such a case, an elderly man with an enormous thyroid tumor just ready to perforate the skin of the neck over an area of moderate size, and evidently malignant, but who yet was in fair general health, suffered but little pain, had only moderate dyspnea on exertion, and some congestion of the face. He desired me to remove the tumor. Being young, inexperienced, and rash, I attempted to remove the growth, but was obliged to desist on account of bleeding. At the autopsy, which was made at no very remote date, the tumor tissue was found to pass into the thorax and to completely surround the aorta. Except the intrathoracic part, and over a rather small area in the upper part of the neck, the very large tumor was surrounded by a fairly thick connective-tissue capsule, perforated, however, by numerous large vessels.

Scirrhous carcinoma occurs in elderly people, and is much less common than the alveolar form. The tumor is rarely large, is characterized by stony hardness, and often produces marked pressure symptoms, although the duration of life is longer than in the alveolar form. On section the tumor shows a structure of firm fibrous tissue, with occasional alveoli containing cells in a condition of fatty degeneration, and granular material. At the advancing border the alveoli with strings and nests of epithelial cells are more numerous. Here, as elsewhere, the neighboring tissues are slowly but continuously invaded with the formation of dense masses and strands of contracting fibrous tissue. Often the gland is diminished rather than increased in size. The involvement of the lymph nodes greatly aids in the diagnosis.

Diseases of the Thymus Gland.—The thymus usually undergoes atrophy, and is normally represented at birth by a mass of fatty tissue lying in the anterior mediastinum, behind the sternum, above the pericardium, and between the innominate and left common carotid arteries, in which, however, some residue of gland tissue has been demonstrated. It may persist in adult life, but is very rarely of pathological consequence except when it becomes the seat of sarcoma.

Status lymphaticus.—The chief surgical interest in the organ is that in the so-called "status lymphaticus" enlargement of the thymus is associated

with general hyperplasia of the lymph nodes, congenital narrowing of the aorta and of the entire arterial system. The condition resembles persistent chronic chlorosis, with a decided feebleness of constitution, such that these individuals suffer from heart and respiratory failure of a serious and even fatal character from slight depressing causes. Injuries and operations of a trifling character and the administration of anesthetics are often followed by death. Death may occur suddenly at any time during anesthesia, with the symptoms of cyanosis or paleness, shallow respiration, dilated pupils, and a failing heart which does not readily respond to stimulation, or the death may be delayed for some hours. The pulse is apt to be rapid during and after the anesthesia, and heart failure comes on gradually or quickly, with coincident respiratory failure, unconsciousness, and death. In these cases the thymus is regularly found enlarged, but never enlarged enough in the adult cases to compress the trachea. The lymph nodes are moderately enlarged throughout the body. The aorta is often narrower than normal. The spleen is usually somewhat enlarged.

The diagnosis of the status lymphaticus is important because such patients should not be anesthetized nor operated upon if it is possible to avoid it. The enlargement of the thymus and the narrowness of the aorta can hardly be made out during life. The signs which would lead to a suspicion of the disease are palpable lymph nodes in regions where they are superficial; rarely the mesenteric glands (Ewing), a flabby and anemic habitus, enlarged tonsils, and the presence of adenoids; a history of attacks of syncope and of a tendency to dyspnea and respiratory failure. Apparent smallness of the principal arteries. A certain proportion of the cases are associated with exophthalmic goiter, and in some there are the signs of rachitis in early life.

In infants and children a few cases of actual compression of the trachea by an enlarged thymus have been recorded, producing severe dyspnea, which has in several instances been permanently relieved by removing a portion of the gland, pulling the remainder up into the neck and stitching it fast to the most convenient tissues, thus anchoring it.

Sarcoma of the Thymus.—Sarcoma of the thymus is very rare. The symptoms are those of a tumor in the mediastinum compressing the viscera, causing also dullness on percussion. A fluoroscopic examination or a radiograph might establish the probable diagnosis of a mediastinal tumor.

THE LARYNX AND TRACHEA

Examination.—The larynx and trachea can be examined by external inspection and palpation. Some data in cases of gross lesions, whether due to injury or disease, may thus be obtained. The larynx may be examined by the forefinger inserted into the mouth, and the presence of foreign bodies, stenoses, tumors, and inflammatory exudates and abscesses may thus be detected. Inspection of the larynx with the laryngoscopic mirror furnishes more information than other methods. Properly to interpret the laryngoscopic picture of

pathological conditions requires much training and experience. The technic of the examination can only be acquired by practice, best upon the normal subject. The student may indeed practice in front of a mirror upon his own person. In this manner he may familiarize himself with the appearances of the healthy larynx, and acquire the manual dexterity necessary for the successful examination of cases of disease. Endolaryngeal operations are rarely attempted except by specialists, and a high degree of skill, only to be acquired by long practice, is essential for their performance. For the practice of laryngoscopy the source of illumination may be sunlight, an electric bull's-eye lamp, an Argand gas burner behind a bull's-eye lens, a good oil lamp, or an electric headlight worn upon the forehead; in this case the head mirror is dispensed with. A centrally perforated concave head mirror worn upon the forehead, the central perforation opposite one or other eye of the operator, is commonly used to reflect light into the throat and illuminate the laryngoscopic mirror. Laryngoscopic mirrors are made in several sizes; the largest mirror should be used when practicable. A laryngoscopic mirror is now made with a small, cold electric light attached. I have found it convenient. Cocainization of the pharynx may precede the examination in irritable and difficult cases. In studying the laryngoscopic picture of pathological conditions it is to be borne in mind that the view obtained is of the surface merely; that some portions of the larynx are inaccessible to direct vision, and that many of the structures are seen foreshortened. The extent of a lesion a part of which only can be seen may be much greater than appears. It is important, therefore, to make the examination in the most painstaking and thorough manner, and to bring into view in succession every part of the larynx accessible to vision. The examination is conducted as follows: The room should be darkened; the patient and surgeon sit facing one another, and close together. The source of light should be on a level with and close to the patient's ear. If the surgeon looks through the head mirror with his left eye, the light should be opposite the patient's right ear, and *vice versa*. The patient sits with his shoulders thrown a little forward and his chin slightly elevated. He is then directed to open his mouth widely and to thrust out his tongue. The tongue is then held with a piece of gauze or a napkin either by the patient or by the surgeon. The head mirror is then focused and rotated until the light is concentrated upon the uvula. The laryngoscopic mirror is then warmed by holding its glass surface for an instant over a lamp until a film of moisture forms upon the metal surface of its back and disappears. Its temperature is then tested by the surgeon upon the back of his hand. Holding the handle of the mirror like a pen, he introduces it flatwise into the patient's mouth, without touching the tongue, until it rests against the uvula, which is pushed a little upward and backward, but not into contact with the posterior pharyngeal wall; the handle of the instrument is then elevated a little and approached to the left corner of the patient's mouth. The larynx will then come into view, and by slight movements of the mirror the various parts may be inspected. The front

part of the larynx, the epiglottis, anterior commissure, etc., appear at the top of the mirror; the posterior commissure, arytenoids, etc., at the bottom. The patient is directed to pronounce the vowel "e," and then to breathe naturally, showing the vocal cords in the position of phonation and at rest respectively. In the first instance the vocal cords are seen close together throughout, and parallel or separated posteriorly by a small triangular space, indicating the ligamentous and cartilaginous portions of the cords respectively. During natural breathing the cords are separated, leaving a triangular space—the rima glottidis—between. During deep inspiration they separate more widely, and one can see several rings of the trachea, or sometimes the bifurcation of that tube. The parts that should be seen are the true and false vocal cords, the anterior and posterior commissure, the ventricles between them, the arytenoids, the aryteno-epiglottic ligaments, the epiglottis, the base of the tongue, and sinus pyriformis and glosso-epiglottic ligaments. The movements of the larynx should be carefully observed. The normal color of the different parts can be best studied by direct observation. The greatest gentleness and steadiness are essential to conduct the examination properly. Certain obstacles may prevent a satisfactory examination: 1. An unusually thick tongue, which arches upward and obstructs the view; this can be overcome by the use of a tongue depressor. 2. An intolerant and irritable pharynx, overcome by the use of cocain. 3. Enlarged tonsils; cocain and the use of a rather large mirror with which the tonsils may be pressed backward, or removal of the tonsils. 4. A recurved and overhanging epiglottis; may be cocainized and held forward out of the way with a soft probe. In order to gain a better view of the posterior commissure and the posterior surface of the trachea the following procedure may be adopted (Killian): The patient stands with his head bent forward, mouth widely opened, chin resting upon the sternum; the tongue is drawn strongly forward out of the mouth. The surgeon sits or kneels in front of the patient, and causes the reflected light from the head mirror to be thrown upward into the pharynx. A rather large laryngoscopic mirror is used in the throat.

It is possible in some cases, by using an especially constructed tongue depressor which at the same time drags the base of the tongue forward, to look through the mouth directly into the larynx when the head is extended (Kirstein). Killian has made use of a straight tube to look into the trachea under cocain anesthesia. The head being fully extended, the tube is passed through the larynx into the trachea, and under suitable illumination the trachea, and to some extent the bronchi, may be examined. A similar instrument, resembling a Kelly's tube for examining the interior of the female bladder, may be introduced through a tracheotomy wound (Coolidge, *New York Medical Journal*, 1899), and the trachea and bronchi explored. Coolidge thus successfully removed a foreign body, a portion of a rubber tracheotomy tube in the right bronchus through a speculum half an inch in diameter and three inches in length. By holding open the edges of a tracheotomy wound a small mirror

may also be introduced into the trachea, and the larynx may be viewed from below upward, the trachea from above downward.

Congenital Defects of the Larynx.—The only congenital defect of the larynx possessing a surgical interest is itself exceedingly rare. It consists of a membranous diaphragm uniting the vocal cords to a variable extent, beginning at the anterior commissure and extending backward, to end in a free concave border. If the membrane unduly narrows the orifice of the larynx it will cause more or less marked dyspnea.

Laryngocele, Tracheocele.—The air-containing tumors connected with the larynx and trachea. Wounds of the larynx and trachea are commonly attended by subcutaneous emphysema more or less extensive. A perforation of the trachea from within by ulceration or abscess of its wall would doubtless cause the same. An abscess of the surrounding tissues which ruptured into the trachea might leave behind a cavity which would fill with air. There occur dilatations of the ventricles of the larynx, either congenital or acquired, which protrude through the thyro-hyoid membrane, and present outside the larynx either in the middle line or laterally. They are reducible tumors; a noise may be heard as the air passes in and out of the sac. They increase in size on coughing, etc., and are resonant on percussion.

Tracheocele—i. e., sacs containing air connected with the trachea—have been described, resulting from dilatation of the mucous glands of the trachea or from defective development of the cartilaginous rings. The diagnosis rests upon the recognition of an elastic reducible tumor connected with the trachea, which increases suddenly in size on coughing, crying, sneezing, etc.; the reduction or inflation of the tumor may be accompanied by an audible sound. On account of the proximity to other air-containing cavities (trachea, lung), a tympanitic percussion note over the sac is not an entirely reliable diagnostic sign.

Wounds of the Trachea and Larynx.—Wounds of the trachea and larynx have already been described.

Scalds, Burns, and the Action of Caustic Fluids on the Larynx.—These injuries occur from inhaling flame, steam, or other hot vapors, and from drinking hot or caustic liquids. The mucous membrane of the larynx above the level of the vocal cords is usually the seat of the injury. As upon the skin, erythema, vesication, or necrosis may follow, according to the degree of heat, etc. There are always evidences of similar lesions in the mouth and pharynx. The important symptoms are dyspnea, pain in speaking and swallowing. Later, inflammatory complications on the part of the mucous membrane of the larynx may necessitate tracheotomy many days after the injury. In the presence of a corresponding history the diagnosis is plain. In the absence of such, the inflammatory lesions might be mistaken for diphtheria.

Foreign Bodies in the Air Passages.—Foreign bodies gain entrance into the air passages from various sources and in various ways. Usually such bodies are aspirated directly from the mouth, by a sudden inspiration caused by

laughing, crying, speaking, falling, being startled, while a foreign body or portion of food is in the mouth. Such accidents are nearly twice as frequent in children as in adults on account of the common practice among children of placing all sorts of objects in the mouth. The variety of objects which have been thus aspirated is endless; among the most common are beans, peas, pins, coins, kernels of grain, nutshells, beads, buttons, etc. Very often the body is taken into the mouth as and for food. It may then consist of fragments of chicken, or other meat bone, or a fish bone, or a partly chewed portion of meat. Greedy adults may also attempt to swallow a piece of meat so large that it becomes impacted in the pharynx or upper end of the esophagus, and a portion of it may rest upon or be aspirated into the larynx. In a considerable number of cases an extracted tooth or a portion of a tooth has entered the larynx. During sleep or alcoholic coma, false teeth, a portion of tobacco, etc., may be aspirated into the larynx, and vomited material in any form of coma. During anesthesia vomited material or pus or blood may enter the larynx and trachea in quantity, on account of the loss of reflex excitability of the mucous membrane caused by the anesthetic. Occasionally the foreign body may gain access to the air passages through a wound—for example, a bullet or a portion of a tracheotomy tube which breaks off and falls into the trachea. Further, as the result of pathological processes, a portion of a tumor may slough off and fall into the larynx, a portion of tuberculous bone from an abscess of the vertebræ, or a caseous bronchial gland, or a foreign body in the esophagus may enter the trachea or a bronchus by ulceration. Living animals may enter the air passages; leeches, when used therapeutically in the mouth, or when taken into the mouth in dirty drinking water; further, flies may enter the open mouth, and partly vomited lumbricoid worms may enter the larynx. The symptoms produced by the entrance of foreign bodies into the air passages depend upon the size, shape, and consistency of the body; further, upon whether it lodges in the larynx or passes into the trachea, remains free, becomes impacted, or passes into a bronchus. If the body is aspirated and completely occludes the larynx, the patient has a feeling of suffocation, makes violent efforts to inspire air, turns blue in the face, and if unable to cough up the offending object and adequate aid is not at hand dies of asphyxia at once. If the body is impacted in the larynx, but does not completely occlude it, the symptoms are, violent spasmodic cough, dyspnea, pain in the larynx, and hoarseness or aphonia, usually gagging and vomiting. If sufficient space remains for breathing, the cough and dyspnea may subside after a time, to recur at intervals. I saw a man who had a ten-cent silver piece impacted transversely in his larynx between the true and false vocal cords; when seen some hours after the coin had lodged he had aphonia, some pain and discomfort, but no dyspnea. A small smooth foreign body may enter a ventricle of the larynx and cause but slight discomfort, remaining indefinitely, or be finally coughed out or aspirated into the trachea. Hard bodies of sharp or irregular contour may wound the mucous membrane, and notably the vocal cords. If allowed to

remain, inflammatory complications occur. The pressure of the body may cause ulceration, which may extend deeply and result in an abscess which burrows outwardly or down the neck, or any one of the large blood-vessels of the neck may be perforated with fatal bleeding. More commonly inflammatory swelling of the mucous membrane of the larynx causes edema glot-

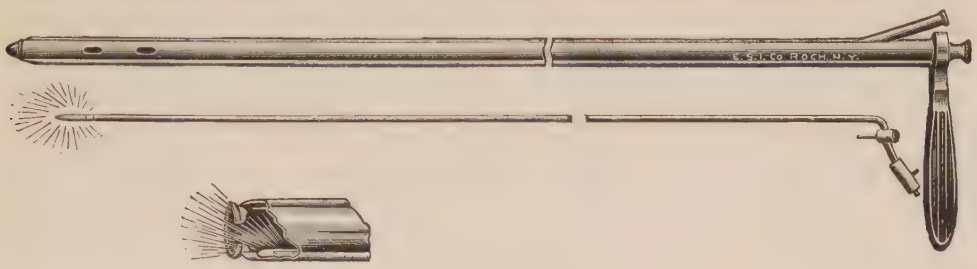


Fig. 210.—Bronchoscope.

tidis and dangerous or fatal dyspnea. Accompanying pressure necrosis of the laryngeal mucous membrane there will be cough with bloody and purulent expectoration.

The large soft masses, such as pieces of meat or other material, either taken into the mouth or vomited during anesthesia, are more apt to cause immediate asphyxia than are small hard objects. Vomited material, or blood or pus or

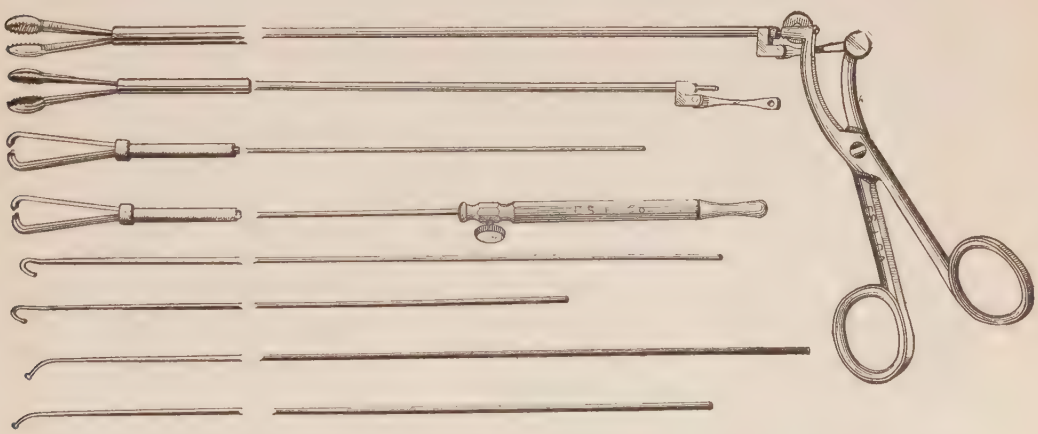


Fig. 211.—Instruments to be Used with the Bronchoscope for the Extracting of Foreign Bodies from the Bronchi and Trachea.

other liquid entering the trachea in large quantity, may cause immediate asphyxia, or gradually increasing dyspnea and cyanosis with death from carbonic-acid poisoning and want of oxygen after some hours. Such accidents occur during anesthesia from aspiration of vomited material or blood or pus, occasionally from clumsy efforts on the part of unskillful persons to wash out the stomach of unconscious or very feeble patients too weak to cough. I once saw a stomach-tube introduced through the larynx of a patient who had taken

strychnin with suicidal intent. Water was poured into the tube, and death occurred from asphyxia in a moment. The trachea and bronchi were found full of water. If food, blood, or pus be aspirated in quantity not sufficient to cause asphyxia, the material finds its way into the bronchi. Septic pneumonia often follows after some days, and will give characteristic physical signs and general symptoms. Hard bodies aspirated into the trachea cause a different train of symptoms, according as they remain movable or become impacted. When the body falls down upon the bifurcation of the trachea a violent spasm of coughing is excited and the body is thrown out violently against the larynx, causing spasmodic closure of the glottis; as it falls again another spasm of coughing occurs, and this series of events continues either until the body becomes impacted or is coughed up or the patient chokes to death. It may be possible by auscultation to hear the sounds made by the body at either end of its excursions. When the body becomes fixed, and does not entirely occlude the air passages, the violent symptoms will often subside completely. There will remain a fixed pain at the point of impaction and more or less dyspnea. Owing to the larger size and direction of the right bronchus, bodies are more apt to enter it than the left. If the body occludes the bronchus, there will be absence of breathing over the affected lung with at first normal resonance, diminished mobility of the affected side of the chest during respiration, and according to some observers diminished vocal fremitus, together with increased breathing over the other lung. If the body has entered a smaller bronchus and occludes it, these signs will be less marked and limited to that portion of lung deprived of air. If the body becomes impacted in a bronchus and does not completely occlude it, there will be an audible whistling sound or coarse râle at the point. Such bodies may remain quiescent for a long time without producing serious symptoms, and may even become encysted, but in most cases they set up ulceration, severe bronchitis, localized septic pneumonia or abscess of the lung, with corresponding physical signs and symptoms. In these cases putrefactive changes often occur, and the breath and sputum acquire a foul putrid odor. The lung may be perforated with the formation of localized purulent pleuritis or empyema, or the lung may become adherent to the chest wall and the abscess may point externally. In such cases the foreign body may be found in the pus when the abscess is incised.

The DIAGNOSIS of the presence of a foreign body in the air passages is sometimes easy, often difficult. In case the foreign body has been aspirated from the mouth, a positive history of such an event is important; in children it can seldom be obtained. It often happens that adults actually swallow a foreign body which scratches the pharynx or esophagus as it goes down. The sore sensation left behind may lead them to believe that the body is still present, and they may locate their sensations in the larynx. A negative physical examination, absence of dyspnea, etc., and the subsequent passage of the body *per anum*, confirms a negative diagnosis. When a patient aspirates food into the larynx during anesthesia, the event is preceded by visible contractions of the

diaphragm, usually by the appearance of vomited material in the mouth, by cessation of breathing or irregular breathing, cyanosis, and, if asphyxia occurs, dilated pupils and death. The rapid introduction of the finger into the back of the throat (a gag having been used to open the mouth and avoid injury to the finger) will usually demonstrate the presence of vomited material. The presence of such material in the trachea can be demonstrated through a tracheotomy wound by aspiration through a soft catheter. In cases of asphyxia in conscious persons, the presence of air hunger, cyanosis, and mental anguish are unmistakable. The foreign body can sometimes be felt by a finger introduced into the back of the throat. In parenthesis I might add that in these cases, unless the body is removed by the finger, almost instant tracheotomy offers the only hope of saving life. In cases less urgent, local pain, hoarseness, or aphonia would lead us to suppose that the body was in the larynx, where a laryngoscopic examination might reveal it. If the signs and symptoms indicated a deeper situation, tracheotomy and one of the methods of examination already indicated would be the proper diagnostic measures to pursue, and that without delay, since the longer the body is allowed to remain in the deeper air passages, the greater the dangers of sepsis and irremediable destruction of lung tissue. I refer to the use of small mirrors in the tracheal wound or inspection of the trachea through a Kelly tube, or better, through a bronchoscope. In many cases, if the body is not impacted it will appear in the tracheal wound at once, and be expelled, or may be extracted. In the case of children, a foreign body in the trachea has been mistaken for croup. The paroxysms of coughing and the dyspnea from a movable foreign body are apt to be intermittent. In croup the symptoms tend to be steadily progressive. Fever does not serve as a differential point because a foreign body in the trachea or in a bronchus may excite fever in a day or two.

Inflammatory Diseases of the Larynx.—Acute and chronic catarrhal laryngitis, as well as spasmodic croup, are scarcely to be regarded as surgical diseases, and can only be mentioned here. Laryngeal diphtheria caused by the Löffler bacillus, or croupous laryngitis caused by streptococci, are of surgical interest only so far as the laryngeal obstruction becomes an indication for intubation of the larynx or tracheotomy. Laryngeal obstruction from diphtheria is observed in childhood with great frequency. Statistics show a gradual increase in the number of cases from birth up to the fourth year of life, after which there is a decline up to the age of fifteen. In older persons obstruction of the larynx from this cause is comparatively rare. In childhood so large a proportion of cases of acute laryngeal obstruction are due to diphtheria that failing a definite history to the contrary, it is almost safe to assume a diagnosis of diphtheria at once. In a large proportion of cases the involvement of the larynx is an extension from diphtheria of the fauces and nose. Less commonly the larynx is primarily affected, rarely the trachea and bronchi. The pathological diagnosis is made by the recognition of a croupous inflammation in the pharynx on inspection or in the larynx by laryngoscopy, and by obtain-

ing smears and cultures of the Löffler bacillus from the throat. It is not always necessary to obtain the bacilli from the actual seat of the false membrane; a swab swept across the pharynx and tonsils will usually give positive results. In the cases of secondary involvement of the larynx the symptoms of respiratory obstruction will be preceded by the local and constitutional signs and symptoms of nasopharyngeal diphtheria. When the diphtheria is secondary to other infectious diseases—measles, scarlet fever, etc.—the symptoms of these diseases will have been present. The symptoms referable to the larynx usually begin with cough and hoarseness. The cough often has a peculiar barking quality more or less characteristic of laryngitis. In the somewhat rare cases beginning below the larynx the signs and symptoms of croupous bronchitis, cough, expectoration, dyspnea, and cyanosis will precede the symptoms referable to the larynx. Gradually the symptoms of obstruction appear, the cough loses its resonant character, the voice becomes more and more feeble until aphonia is established. Transient attacks of dyspnea and coughing occur, sometimes with the expulsion of a portion of false membrane or a mass of mucopus. Gradually respiration becomes labored. Inspiration is prolonged and accompanied by a peculiar and characteristic stridor. The accessory muscles of respiration are brought more and more into play; the nostrils dilate, the muscles of the neck contract, the shoulders are elevated. Expiration is also labored, and is accompanied by an audible laryngeal sound. As the dyspnea increases the patient is unable to fill the thorax with air. The supraclavicular fossæ show depressions, the epigastrium is sunken, the intercostal spaces show grooves in thin patients; attacks of violent dyspnea occur, during which the child becomes cyanotic, struggles wildly for breath, grasps its throat, tries to scream, and finally falls back exhausted. The carbonic-acid poisoning gradually increases, and the excitement is succeeded by somnolence and stupor. The respirations, at first rapid, become slower than normal, the pulse more and more rapid and feeble, the nails and mucous membranes blue. This condition ends in death. The general and local symptoms are so characteristic of progressive laryngeal dyspnea that they are to be recognized at a glance. The picture is painful in the extreme. After the condition of stupor is reached an inexperienced observer might think the disappearance of the active dyspnea a sign of improvement. In adults the diagnosis of diphtheritic laryngitis can be made by a laryngoscopic examination and concomitant signs and symptoms. In children dyspnea from a retropharyngeal abscess can be recognized by palpation and inspection of the pharynx. Tumors and inflammatory exudates in the substance of or around the larynx usually give definite signs and symptoms. Spasmodic croup occurs in sharp intermittent attacks, without the local and general symptoms of diphtheria.

Edema laryngis.—Local trauma—mechanical, thermal, or chemical—acute inflammations of many kinds in the tissues of the larynx or in the vicinity (erysipelas), and ulcerative processes of the laryngeal mucous membrane, may give rise to inflammatory edema sufficient to close the laryngeal orifice and cause

dyspnea or asphyxia. The edema of cardiac and renal disease may do the same, as well as emphysema of the lungs. Further, tumors in the neck and thorax, causing venous obstruction, notably large tumors of the thyroid, occasionally aneurism of the aorta. In the course of acute infectious diseases—typhoid fever, scarlatina, small-pox—such edema may occur. The swelling of the aryteno-epiglottidean folds of mucous membrane is largely the cause of the obstruction; such swelling can usually be felt by the forefinger introduced into the throat, and may be readily seen in the laryngoscopic mirror. In some cases the swollen epiglottis may hide the laryngeal opening; in others the swollen ridges formed by the aryteno-epiglottidean folds will be readily visible; in other cases of inflammation of the submucous tissues of the larynx the swelling will lie below the level of the vocal cords. Some of these cases end in suppuration, and it may be possible to see the yellow color of the pus beneath the thinned mucous membrane. The peculiarity and interest of the condition lies in the fact that the obstruction may occur suddenly and reach a dangerous degree in a very short time. This is notably the case when moderate degrees of stenosis exist as the result of pressure upon the larynx and trachea by tumors or exudates; or when ulcerative processes or tumors exist within the larynx itself; a moderate swelling of the mucous membrane may then be sufficient to cause dangerous obstruction.

The symptoms of laryngeal obstruction due to edema laryngis do not differ materially from those described under diphtheria, except that they are sometimes very acute in their onset. The voice is changed, becoming hoarse and raucous; later, weakened or lost. The dyspnea is at first inspiratory merely; later, expiration may also be interfered with. When due to acute inflammation or to the presence of an abscess in the submucous tissue of the larynx there will be pain more or less severe. The careful surgeon will be forewarned and prepared in all such cases to afford relief by tracheotomy when occasion requires it. The condition is to be differentiated from the dyspnea symptomatic of cardiac, renal, or other asthma, by the absence of the sounds of laryngeal obstruction, and the negative laryngoscopic examination in these latter conditions.

Perichondritis of the Laryngeal Cartilages.—Acute purulent inflammation of the perichondrium of the cartilages of the larynx occurs as the result of infected wounds of the larynx; in the presence of impacted foreign bodies which have caused local ulceration, secondary to ulcerative processes in the larynx, tubercular, syphilitic, carcinomatous, or other; as a primary infection with pyogenic organisms, the point of invasion being unknown; as a secondary or metastatic process in the course of acute infectious diseases, notably typhoid fever, the acute exanthemata, and in the course of generalized septic infections, pyemia, septicemia. The arytenoids and the cricoid, rarely the thyroid cartilage, are the seat of the inflammation. The process resembles a purulent periostitis in that the pus accumulated beneath the perichondrium raises this layer from the surface of the cartilage, and more or less extensive necrosis of the

cartilage follows. The abscess may rupture into the larynx, the esophagus, or pharynx, or into the soft parts of the neck in front of the larynx, or posteriorly. The pus may be present under the skin, perforate it, leaving a fistula leading to dead cartilage, or burrow downward in the neck. Traumatic and septic cases run an acute course; those due to tubercular, syphilitic, or cancerous ulceration of the larynx are chronic. The signs and symptoms are: Local pain on speaking and swallowing, a change in the voice and dyspnea, together with the discovery of a localized abscess connected with the larynx, either externally or by laryngoscopic examination; later, the discovery of exposed cartilage with a probe, after the abscess has ruptured or been evacuated, are the data from which a diagnosis is to be made. The sequelæ of the condition are sometimes serious. The loss of portions of cartilage may lead to permanent changes in the voice or to immediate dangerous stenosis of the larynx. These patients are sometimes obliged to wear a tracheotomy tube permanently.

Tuberculosis of the Larynx.—Tuberculosis of the larynx is usually secondary to tuberculosis of the lungs, occasionally primary in the larynx itself. Submiliary tubercles or more diffuse areas of tubercle tissue form in the mucous membrane, notably in the posterior part of the larynx, break down, and create tubercular ulcers similar to other tubercular ulcers of the mucous membrane. The symptoms and signs are local pain on swallowing and speaking, hoarseness, or almost complete aphonia, an irritable condition of the larynx, causing a frequent painful cough, and a muco-purulent expectoration. Recognition of infiltrations and tubercular ulcerations in the larynx, and the presence of tubercle bacilli in the sputum, or in the discharges from the ulcerating surfaces, establishes the diagnosis. A unilateral involvement of the larynx and extreme pain on swallowing both favor the diagnosis of tuberculosis.

Syphilis of the Larynx.—The larynx is affected in a pretty large proportion of syphilitics. In the early secondary stage the general catarrhal and erythematous lesions of the throat may affect the larynx also; later, mucous papules in the form of flat condylomata may occur, and, untreated, may cause stenosis and dyspnea. The tertiary lesions consist of gummata or of diffuse infiltrations of the tissues of the larynx. The gummata break down, forming crateriform ulcers with a red border and a base of characteristic gummy material. The diffuse infiltrations lead especially to cicatricial contractions and functional disturbances of the larynx, sometimes to stenosis. As already noted, necrosis of the cartilages may occur. The diagnosis depends in any case upon a syphilitic history, the presence of other manifestations, the improvement produced by iodid of potassium, the appearance of the ulcers, absence of involvement of the lymph nodes in tertiary lesions, even though of long duration. Syphilitic gummata are more apt to involve the front part of the larynx and epiglottis. Tuberculosis, as stated, the posterior part.

Fistula and Chronic Stenoses.—It is to be noted that any of the suppurative and ulcerative lesions of the larynx, whether due to pyogenic, tubercular, or syphilitic infection, may be followed by a fistula of the larynx opening upon the

skin of the neck; or to chronic stenosis due to cicatricial contraction. In rare cases a necrotic or ulcerative process may lead to fistulous communication between the trachea and the esophagus. The symptoms of this condition are due to the entrance of solids and liquids into the trachea during the act of swallowing. The patients choke and cough in a manner similar to that which we all suffer from when we have "swallowed the wrong way." The diagnosis may be confirmed by passing a stomach-tube down the esophagus; so long as the orifice of the stomach-tube remains above the fistulous opening a stream of air will issue from the external orifice of the tube during forced expiration. The diagnosis of the chronic stenoses of the air passages is generally self-evident from the history, the condition of chronic dyspnea, and often from the presence of scars and irregularities in the contour of the larynx and trachea, and from the laryngoscopic examination.

Benign Tumors of the Larynx.—The commonest benign tumors of the larynx are papilloma and fibroma. Chondroma myoma, lipoma, adenoma, cysts, and angioma have also been observed.

Papilloma.—The papillomata of the larynx form wartlike excrescences having a cauliflower surface, resembling in conformation the acuminate warts of the prepuce, etc. They are sessile or pedunculated tumors, single or multiple; situated on the true or false vocal cords more often than elsewhere, sometimes in the ventricles or on the epiglottis. They may be scattered diffusely over the mucous membrane of the larynx. They occur more often during the first three decades of life than later; after the age of forty years they are apt to be the forerunners of cancer. The symptoms produced vary with the size and situation of the tumors. Hoarseness or loss of voice, a sensation of irritation, "as though a foreign body were in the larynx," cough, occasionally dyspnea—if the tumors are numerous or large—are complained of. Laryngoscopic examination renders the diagnosis plain. It is to be borne in mind that the removal of the tumors, if they grow from the vocal cords, may leave a permanent change in the voice, and that recurrences and cancerous degeneration are not uncommon.

Fibroma and Chondroma.—Fibroma occurs on the vocal cords, usually near the anterior commissure. Nearly all the cases have occurred in men. The tumors are covered by mucous membrane, normal or congested in appearance. They are usually solitary, and rarely grow to a large size—from the size of a pea to that of a small olive being the ordinary limits. They are at first sessile tumors of even, smooth surface; later they may become pedunculated and of uneven contour. They vary in consistence from firm and hard to soft and gelatinous (from myxomatous changes). Like other fibromata their growth is slow. True myxoma is of doubtful occurrence. The symptoms of fibroma are similar to those of papilloma—change of voice, etc. It is possible for a pedunculated tumor to fall into the rima glottidis from time to time, so that the voice may be at one moment normal and at the next hoarse or lost. In children, especially, dyspnea in attacks may occur from time to time. The laryngoscopic examination is all-important for the diagnosis. *Chondroma.*—A

small number of cases only have been observed. The tumors are composed of hyaline cartilage, and grow from the surface of the cricoid, less often from the thyroid and epiglottis, in one or two cases from the arytenoid cartilages. The diagnosis must be made from the hard consistence, the connection with a cartilage, and the slow growth.

Malignant Tumors of the Larynx.—Carcinoma is the common form, sarcoma being relatively rare. The relative frequency of the two conditions is about one to twelve. Sarcoma is most frequent in the fourth, fifth, and sixth decades of life. The seat of the tumor is most often the vocal cords and the epiglottis. On these situations the tumor is usually of the spindle-celled type. In the other portions of the larynx there occur, less commonly, but of far greater malignancy, the small round-celled and alveolar forms (Bergeat). The spindle-celled sarcomata form slowly growing nodular tumors, usually sessile. They show no very marked tendency to infiltrate the surrounding tissues. They are of firm consistence, are usually covered by fairly normal mucous membrane, and rarely ulcerate except when subjected to mechanical irritation. The differential diagnosis from fibroma is scarcely possible except by a microscopic examination. The round-celled and alveolar forms originate in other parts of the larynx, in the ventricles, in the sinus pyriformis, and below the vocal cords. They tend to grow rapidly, to infiltrate the surrounding soft parts; the cartilages usually remain free, although destruction of cartilages has been noted in alveolar sarcoma. They rarely ulcerate, affect the lymph nodes late in the disease, if at all, and are said not to spread upward above the larynx involving the pharynx, as is often the case with carcinoma. In spite of these characters, however, a differential diagnosis from carcinoma is not always possible without a microscopic examination. The clinical symptoms of a rapidly growing tumor causing symptoms referable to obstruction of the larynx are present.

Carcinoma of the Larynx.—Carcinoma of the larynx occurs after the age of forty years in more than eighty per cent of all cases; the disease is much more frequent in men than in women; excessive smoking and drinking are believed to favor its occurrence. The flat epithelial type of cancer is the common form, cylinder-celled or adenocarcinomata are more rare. The tumor may originate in any part of the epithelial lining of the larynx. In certain cases the larynx is invaded by continuity of structure from primary cancer of the tongue and pharynx. The disease is limited to one side of the larynx in more than half the cases. The original seat of the disease, according to the statistics of Sendziak, who tabulated 273 cases, was the vocal cords in 107 cases; false vocal cords, 23 cases; interarytenoid folds, 15; ventricles, 7; below the glottis, 7; the anterior and posterior surfaces of the posterior wall of the larynx, 33; epiglottis, 24; pharyngeal surface of the posterior wall of the larynx, 18; aryepiglottic folds, 13; sinus pyriformis, 7.

The disease begins as a flat infiltration of the tissues, or as a prominence with a broad, firm base, in either case surrounded by a hyperemic border. The

elevation may have a smooth, nodular, or warty surface, and may be covered by epithelium or excoriated. The resemblance to an ordinary papilloma may be exact. During this stage the spread of the growth may be slow for many months, and a diagnosis, although difficult, is most desirable, since operative removal may result in cure. The symptoms at this stage vary with the seat of the growth. When the tumor arises within the cavity of the larynx and involves a vocal cord, primarily or by extension, or if the movements of the cord are interfered with, by fixation of an arytenoid cartilage or by infiltration of a nerve or muscle; *gradually increasing hoarseness is the first symptom noticed.* In the early stages of these intralaryngeal growths fixation or partial paralysis of one vocal cord is regarded as suspicious of cancer (Semon). If, on the other hand, the epiglottis, the pharyngeal surface of the larynx, or other part not immediately connected with the mechanism producing vocal sounds, is the primary seat of the disease, *pain on swallowing will be first noticed.* In making a diagnosis at this stage the laryngoscopic picture is most important. As was pointed out in another place, the disease is usually more extensive than the picture would indicate. In cases of doubt, examination for tubercle bacilli in the sputum and of scrapings from a raw surface, if such there be, inquiry as to a syphilitic history, the administration of iodid of potassium, and, finally, the removal of a portion of the growth by snare, forceps, etc., or through a subhyoid pharyngotomy, or better by median fissure of the thyroid cartilage, and microscopic study of the tumor tissue, are the means whereby a positive diagnosis may be reached.

The further progress of the disease is characterized by progressive infiltration of the surrounding tissues. The original growth soon loses its sharply marked borders. In some cases the infiltration advances along the surface chiefly, in others more into the deeper tissues. Ulceration occurs early after the process has assumed an active character; the borders of the ulcer are elevated and hard; the base may be necrotic, uneven, and granular, or from it there may sprout papillary outgrowths of considerable size. Thus, in some cases the destructive action is most marked, in others tumor masses of considerable size are formed. Invasion and destruction of cartilages may occur or suppurative perichondritis and necrosis. Secondary involvements of lymph nodes occur late or may be absent. The glands under the sterno-mastoid just below the angle of the jaw are often first affected, and extension of the disease outside the larynx may be followed by enlargement of the glands in the submaxillary triangle. The symptoms, as the disease progresses, are increasing hoarseness and in many cases dyspnea, which gradually or suddenly assumes a dangerous character and may occur in attacks dependent upon inflammatory edema of the mucous membrane; such attacks may be fatal. The stenosis produced by the growth of tumor tissue may be marked, but is sometimes limited by sloughing. There is a cough with a foul, putrid expectoration, sometimes blood-stained; bleeding from the ulcerated surfaces, slight or severe; pain caused by speaking, swallowing, or coughing; later spontaneous pain of a severe

neuralgic character radiating to the ear. In many cases no external palpable tumor is found, nor are metastases in distant organs at all common. As the pain and difficulty in swallowing increase, the patient's nutrition begins to suffer. Death occurs after a duration of rarely longer than two years, from septic pneumonia, malnutrition and exhaustion, or asphyxia.

Tumors of the Trachea.—Fibroma, lipoma, sarcoma, and carcinoma of the trachea have been observed. The carcinomata are more often caused by the extension of carcinoma from neighboring organs than primary in the trachea itself. When primary they occur for the most part in the upper portion of the trachea. The symptoms of tumors of the trachea are chiefly caused by stenosis—i. e., tracheal dyspnea. The diagnosis can sometimes be made by the laryngoscope, sometimes through a Kelly tube passed through a tracheotomy wound or in one of the other ways mentioned in the beginning of this chapter.

CHAPTER XX

THE ESOPHAGUS

TOPOGRAPHY OF THE ESOPHAGUS

The esophagus extends from the pharynx at the upper border of the cricoid cartilage to the cardia of the stomach. It is between nine and ten inches in length, and begins opposite the intervertebral disc, between the fifth and sixth cervical vertebra, and ends opposite the body of the tenth dorsal vertebra. The tube is nearly vertical, but exhibits slight curvatures in two planes: an antero-posterior curvature corresponding to the anterior surface of the bodies of the vertebræ, convex forward in the neck, concave forward in the dorsal region. Two lateral curvatures; beginning above in the median line, it deviates slightly to the left as far as the root of the neck, where it is about one half inch to the left; returns again to the middle line as it descends in the mediastinum; where it again bends to the left as it passes forward to penetrate the diaphragm. The caliber of the tube is about three fourths of an inch, except at three constricted points—opposite the cricoid, opposite the left bronchus, at the place where it passes through the diaphragm. In these situations its diameter is about one half inch. The tube, however, admits of considerable further distention without injury. When empty the lumen is commonly represented by a transverse slit, or occasionally by a stellate orifice. The distance from the incisor teeth to the stomach is from fifteen to fifteen and three quarter inches. From the incisor teeth to the point of bifurcation of the trachea or to the left bronchus is about nine inches. The distance from the cricoid cartilage to the bifurcation of the trachea is about four inches; from the bifurcation to the cardia of the stomach about six inches; from the teeth to the beginning of the esophagus about six inches.

RELATIONS OF THE ESOPHAGUS

Except at the lower end, the esophagus is surrounded by a loosely meshed layer of connective tissue; it is therefore somewhat movable, and its curves can be eliminated during the introduction of a straight instrument. "It is in relation in the neck in front with the trachea; in the lower part of the neck with the thyroid gland and the thoracic duct, where it projects to the left side. Behind it rests upon the vertebral column and longus colli muscle. On each

side it is in relation with the common carotid arteries, especially the left, and part of the lateral lobes of the thyroid gland; the recurrent laryngeal nerves ascend between it and the trachea. In the thorax it is at first situated a little to the left of the median line. It then passes behind the left side of the aortic arch, and descends in the posterior mediastinum, along the right side of the aorta, nearly to the diaphragm, where it passes in front and a little to the left of the artery, previous to entering the abdomen. It is in relation in front with the trachea, the arch of the aorta, left carotid, left subclavian arteries, the left bronchus, and the posterior surface of the pericardium: behind it rests upon the vertebral column, the longus colli and the intercostal vessels, and below, near the diaphragm, upon the front of the aorta: laterally it is covered by the pleurae; the vena azygos major lies on the right and the descending aorta on the left side. The pneumogastric nerves descend in close contact with it, the right nerve passing down behind the left nerve in front of it." (Gray.)

METHODS OF EXAMINING THE ESOPHAGUS

The various methods of examining the esophagus for diagnostic purposes are: I. The examination with bougies or other similar instruments. II. Palpation. III. Auscultation. IV. Percussion. V. Direct inspection through the esophagoscope. VI. X-ray examination.

I. **Examination with Bougies, etc.**—The bougies, stomach-tubes, probangs, coin-catchers, and other similar instruments introduced into the esophagus for diagnostic purposes are made of some flexible material and of various shapes and sizes. The solid bougies are made of a silk or cotton fabric, impregnated and coated with a varnish, which is hard and rigid when cold but becomes soft and pliable when warmed. The bougies are cylindrical, and are made in graduated sizes. Before their introduction they are dipped in hot water, when

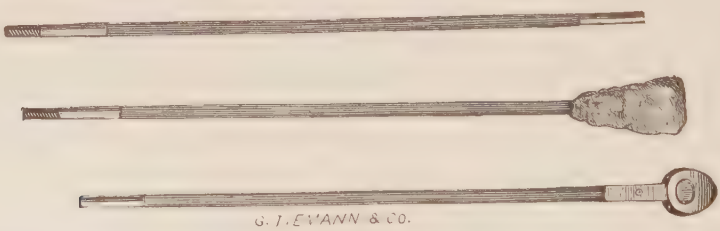


Fig. 212.—Coin-Catcher and Sponge Probang for Extracting Foreign Bodies from the Esophagus.

they may be bent to any desired curve. Such bougies are also made hollow with a terminal central opening or a lateral eye like a catheter. For easier engagement in a stricture, or for the detection of the same, these bougies are sometimes made with a tapering, rounded point or with a pear-shaped or olivary extremity. Olivary bougies are also made with a shaft of whalebone

or metal, graduated in centimeters or inches, ending in a metal tip with a screw thread, to which may be attached olivary bodies composed of ivory, hard rubber, or metal of graduated sizes. A slender, flexible guide may be substituted in cases of narrow stricture. For passing very narrow strictures it is sometimes necessary to use filiform bougies composed of whalebone or silk. In certain cases a large, hollow bougie with a terminal opening is introduced as far as the stricture, and the slender guides are passed inside of it one after another, when one of these may often find and engage in the orifice of the narrowed portion of the canal.

A convenient method of passing strictures of the esophagus was devised by Dunham. He causes the patient to swallow water, and at the same time

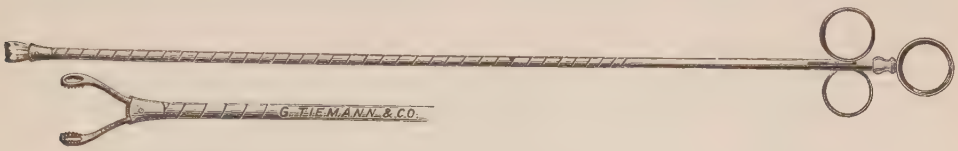


Fig. 213.—Spring Forceps for Seizing Foreign Bodies in the Esophagus.

a thread or slender cord; the water carries the thread through the stricture into the stomach. The thread may be used to pull larger cords or instruments into the stomach through a gastrostomy wound, or may be used to enlarge the stricture. (See works on Surgery of Stomach and Esophagus.) Soft-rubber stomach-tubes of graduated sizes, usually made with a terminal or a lateral eye or both, are useful for diagnostic purposes as well as for feeding persons unable to swallow—lunatics, unconscious persons, etc. Such tubes are also used to empty and cleanse the stomach, and for various therapeutic and diagnostic purposes some of which will be noted in other places. The coin-catcher,

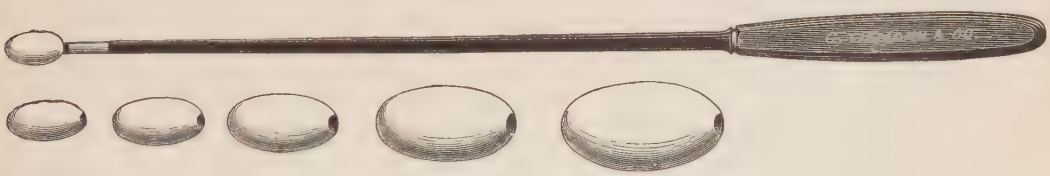


Fig. 214.—Graduated Bulbous Bougies for Detecting Strictures of the Esophagus.

the sponge and bristle probangs, are therapeutic rather than diagnostic instruments, and need no description here. They may be used also for the detection of foreign bodies.

The introduction of bougies, etc., into the esophagus should be accomplished with extreme gentleness lest injury be done to the esophagus or surrounding structures; this caution is especially true when stricture of the esophagus is present from any cause—notably from malignant or inflammatory disease, or when a sharp, hard foreign body is impacted in the gullet. A false passage may easily be made, to be followed by extravasation of septic material into the surrounding tissues and dangerous or fatal suppurative or phlegmonous

inflammation in the neck, mediastinum, pleura, or pericardium. The great vessels in contact with the esophagus may also be wounded by the instrument itself, or by undue pressure upon a foreign body, in the effort to extract it or push it into the stomach. Before introducing an instrument into the esophagus in cases presenting symptoms of chronic obstruction, it is wise, if the patient be no longer young, to examine the thorax for the signs of aneurism of the aorta. The introduction of esophageal bougies in cases of aneurism has been followed by rupture and fatal bleeding in a number of instances.

Method of Introducing Flexible Instruments into the Esophagus.—The method of introducing flexible instruments into the esophagus is as follows: The patient sits, the head inclined slightly forward, thus tending to separate the larynx a little from the posterior pharyngeal wall and to avoid the possibility of the tip of the instrument entering the larynx. The bougie may be simply wet in water, other lubricant being scarcely necessary. The patient's mouth being open, the surgeon places his left forefinger gently upon the dorsum of the tongue, depressing it and at the same time drawing it a little forward. The bougie is held lightly in the right hand and is inserted into the mouth against the posterior pharyngeal wall, and gently pushed onward and downward while the patient is directed to swallow, when the instrument usually glides readily down the esophagus and into the stomach. If uncontrollable retching occurs, or the patient chokes, he should be directed to breathe slowly and deeply; or the posterior wall and lower limit of the pharynx and the base of the tongue may be painted with five- to ten-per-cent cocain solution. In unconscious patients, or those with anesthesia of the larynx, the tip of the instrument must be carefully directed backward with the left forefinger as a guide, to avoid the larynx. A tumor or retropharyngeal abscess or a marked kyphosis in the cervical region may render the introduction more or less difficult, as may, of course, stricture of the upper end of the esophagus. If the tube checks at any point, a slight withdrawal and gentle advance will be sufficient to enable it to pass except in the presence of a real obstruction. In delirious or insane patients, or in the presence of lock-jaw from any cause, a slender, long tube may be passed through the nose into the pharynx, and so into the gullet. After a solid instrument has once entered the esophagus through the mouth, it is of advantage to direct the patient to incline his head backward so that the path of the bougie may be more straight and the sensation of obstruction may be more readily communicated to the surgeon's hand. The diagnostic value of the bougie, etc., will be considered under the different pathological conditions in which they are used.

II. **Palpation.**—Palpation of the esophagus is only possible in its upper part. Through the mouth the forefinger may be introduced into the beginning of the gullet, and a foreign body, a stricture, or the presence of a tumor may thus be determined. External palpation may permit the detection of a large, hard, foreign body, possibly carcinomatous infiltration of the surrounding tis-

sues, or of a large diverticulum filled with food or with air. Such tumor may diminish in size on manipulation.

III. **Auscultation.**—Certain sounds can be heard through a stethoscope placed along the line of the esophagus in the neck, or in other situations to be noted, during swallowing. These sounds vary somewhat in normal and pathological conditions; they are not of great diagnostic value. The first sound is supposed to be caused by air compressed in the pharynx forcing the food down the gullet during the act of swallowing; the sound is seldom present, and has no pathological significance. The second sound is said to be caused by the passage of air and food through the cardiac orifice into the stomach; it is to be heard in the back or along the costal border in front, to the left of the middle line, some seconds after the food is swallowed. These two sounds are said not to be present together. The second is absent in cases of narrow stricture at or above the cardia (v. Hacker).

IV. **Percussion.**—Percussion is rarely of value in diseases of the esophagus. A diverticulum filled with gas or food, if in the upper part of the gullet, will give a tympanitic or dull note respectively.

V. **Direct Inspection, Esophagoscopy.**—v. Mikulicz first used a straight metal tube to inspect the interior of the esophagus. While most of the diseases of the gullet can be diagnosticated without this aid, the method furnishes accurate information, and is not very difficult to apply. The instruments consist of straight metal tubes from one half to three quarters of an inch in diameter. These tubes are made in several different lengths, according to the depth of the lesion to be examined. The lower end of the tube is cut off squarely or obliquely. A conoidal hard-rubber obturator fills this gap during the introduction of the instrument. The upper end of the tube is arranged for the attachment of a suitable electric light and lens for illumination, or a tube may be used which has a small, shaded electric light in its interior near the lower end. The latter arrangement is simple, and more satisfactory on account of the great length of the tube. It is desirable that the patient's stomach should be empty when the tube is introduced, otherwise regurgitation of food may take place into the tube, notably when it is introduced as far as the cardia. Such soiling, when it occurs, must be wiped or washed away, or, if fluid, may be sucked out with a catheter and hand syringe. The patient should be clad as for a surgical operation, so that respiration may be free. The lower pharynx is thoroughly painted with cocain solution (ten to twenty per cent) several minutes before the examination; the tube may be slightly lubricated with a soluble sterile lubricant; Iceland-moss jelly, for example, or glycerin, although this is not always necessary. The patient then sits upright on the table, the mouth is widely opened, the surgeon depresses and draws forward the base of the tongue with his left forefinger, and introduces the tube with its obturator in place to the back of the pharynx and downward; the patient then extends his head so that the mouth and gullet may be as nearly as possible in the same line; the tube is gently pressed on-

ward until it engages in and passes the narrow upper end of the esophagus, when it usually moves on easily without much resistance until it reaches the sphincter of the cardia.

The tube may also be introduced and the examination conducted with the patient lying on his side, the head being extended. When the esophagoscope

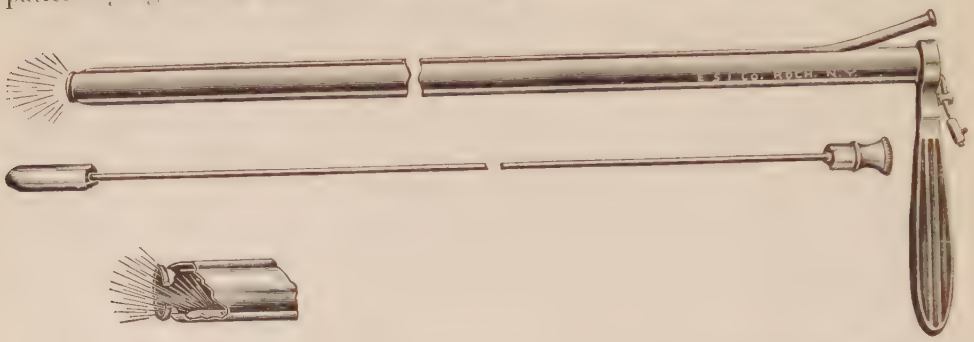


Fig. 215.—Esophagoscope with Small Electric Light Near its Lower Extremity for Examining the Esophagus by Direct Vision.

or any hard or partly flexible instrument is to be introduced under anesthesia, the patient is placed on his back, with the head hanging over the end of the table, properly supported and extended sufficiently to permit a straight instrument to pass through the mouth and down the gullet. The surgeon stands at the head of the table. When searching for a hard, foreign body, the surgeon may be deceived by the click made when the instrument strikes the patient's teeth. In such a case the teeth may be covered by a pad of gauze, or the like. If the tube was inserted with the patient sitting up, as soon as the tube is introduced the patient is gently lowered to the dorsal position on the table, with his head hanging somewhat over the edge; the obturator is then removed and the esophagus inspected as the tube is withdrawn. Should the tube check at any point during its introduction the obturator is withdrawn and the seat of the obstruction examined; such may be a foreign body, a stricture (benign or malignant), a diverticulum, or the instrument may have caught in a fold of mucous membrane owing to an improper direction taken by the advancing tube. Inspection will usually enable the surgeon to see how to correct the direction; he moves the tube and the patient's head a little this way and that until the caliber of the gullet centers that of the tube; the obturator is reinserted and the tube pushed on. It is to be remembered that the esophagus inclines forward and to the left after passing through the diaphragm. In the selection of a particular length of tube the surgeon will be guided by the probable seat of the lesion he desires to examine; this may be determined by the previous introduction of a flexible bougie or bulbous esophageal sound.

While in cases of impacted foreign bodies the use of the esophagoscope is always justifiable, in cases of acute inflammation it is not. If an ulcerated carcinoma is present, or in any case where there is reason to suspect that the

integrity of the wall of the esophagus is destroyed or weakened—as in wounds, external or internal—the introduction should be made with the greatest gentleness and care, and the slightest sign of obstruction should be followed by withdrawal of the obturator and inspection of the esophagus. Aneurisms in the thorax and acute or chronic disturbances of respiration of any sort are contra-indications to this method of examination. In cases of malignant disease a small portion of tumor tissue may be removed through the tube and subjected to microscopic examination; the diagnosis is thus rendered certain. Impacted foreign bodies cannot only be seen, but the obstacles to their removal may be appreciated, and often corrected and removed.

VI. **X-ray Examination of the Esophagus.**—The X-rays are sometimes useful for locating such foreign bodies as are recognizable by the X-rays, notably those of metal, bone, glass, china, stone, or other more or less impervious material (see Fig. 216). If the foreign body is large it may be located with the fluoroscope by viewing the neck from various directions. If it is small it will be necessary to make one or more radiographs. These may be taken from side to side or antero-posteriorly; in neither case is it possible to get a very sharp picture of the body on account of its necessary distance from the photographic plate. When the picture is taken antero-posteriorly, the plate should be placed in front, the X-ray tube behind the patient. When the foreign body lies in the thoracic portion of the esophagus an effort should be made to take the picture obliquely, in order to avoid the confusion of shadows caused by the spine and the heart. Diverticula and dilatations of esophagus may sometimes be demonstrated by the X-rays. The patient is caused to swallow a quantity of an emulsion of bismuth subnitrate. This material entering the diverticulum or remaining in the dilated portion of the esophagus, casts a shadow on the photographic plate or on the fluoroscope, and the location and size of the diverticulum may thus be demonstrated. A diverticulum may also be demonstrated by passing an esophageal bougie containing a lead core or filled with fine bird shot; when the bougie has entered the diverticulum the

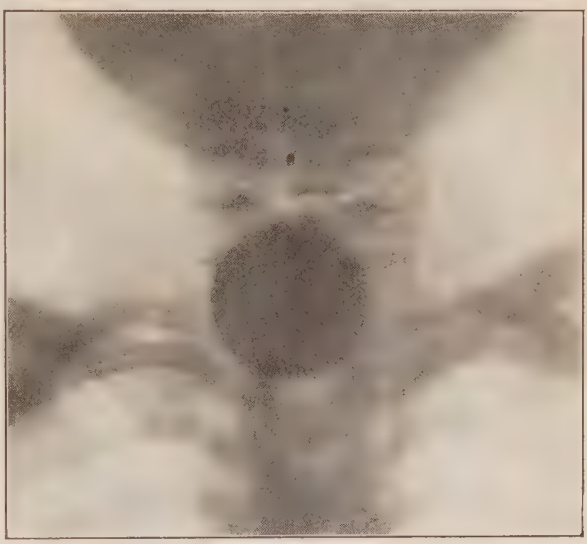


Fig. 216.—X-ray Picture of the Thorax and Neck of a Boy Aged Ten, who swallowed a Fifty-Cent Silver Piece. The coin became impacted in the esophagus, as shown in the illustration. During my efforts to remove it, it passed on into the stomach. (Author's case.)

patient is examined with the fluoroscope, or a radiograph is taken, and the abnormal position of the bougie may thus be shown.

CONGENITAL DEFECTS OF THE ESOPHAGUS

Imperfect development of the gullet may exist alone or be associated with other defects; in either instance the children are rarely viable; the surgical importance of these conditions is therefore small. The most common deformity is that the upper portion of the gullet ends below in a blind sac, either

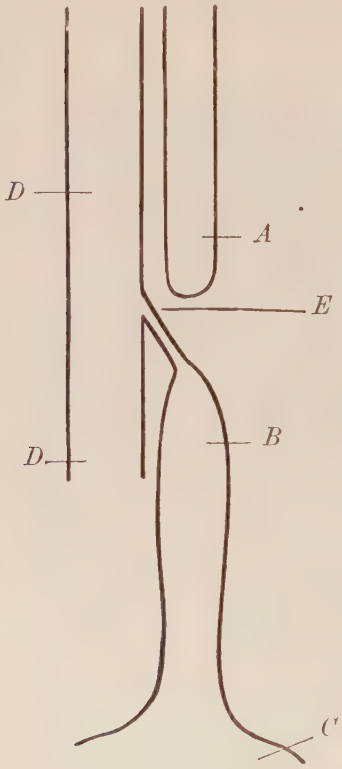


Fig. 217.—Congenital Atresia of the Esophagus. Diagram to illustrate the condition found in the body of an infant brought to the anatomical department of the Columbia University Medical College. The drawings and diagram are shown through the kindness of Dr. C. R. L. Putnam. There was an atresia of the esophagus and an abnormal communication between the lower segment of the esophagus with the trachea.

A. Upper portion of the esophagus ending below in a blind sac.
B. Lower portion of esophagus ending below at *C* in stomach.
D. Trachea.
E. Abnormal communication between trachea and esophagus.

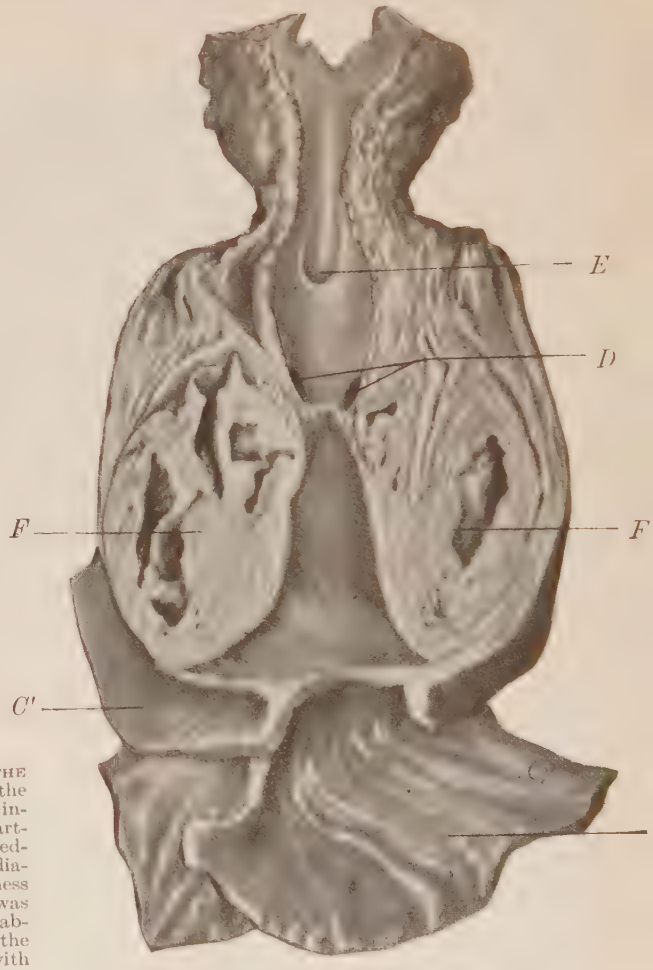


Fig. 218.—Anterior View of Specimen.

C'. Diaphragm.
C. Stomach.
D. Bifurcation of bronchi.
E. Abnormal communication between trachea and gullet.
F. Heart.

normal in size or dilated, and usually intrathoracic. The lower portion is often short and narrow, and may communicate with the trachea by a large or narrow orifice. Such children are unable to swallow; attempts at nursing are followed by regurgitation of food through the nose. There may be a gurgling sound during respiration, when mucus enters the trachea from the stomach. Death occurs in less than a fortnight, from inanition or pneumonia. In some cases the esophagus is of normal size and patent, but a communication exists between gullet and trachea. If the communication is small or, as sometimes happens, does not leak, no symptoms will occur. If food, etc., passes into the trachea, there will be attacks of coughing and choking, followed sometimes by septic pneumonia. Congenital strictures of esophagus are very rare, a few cases having been observed at autopsy; the individuals had a history of difficulty in swallowing. Congenital dilatations and diverticula of the esophagus are rare. They will be considered under Diseases of the Esophagus.

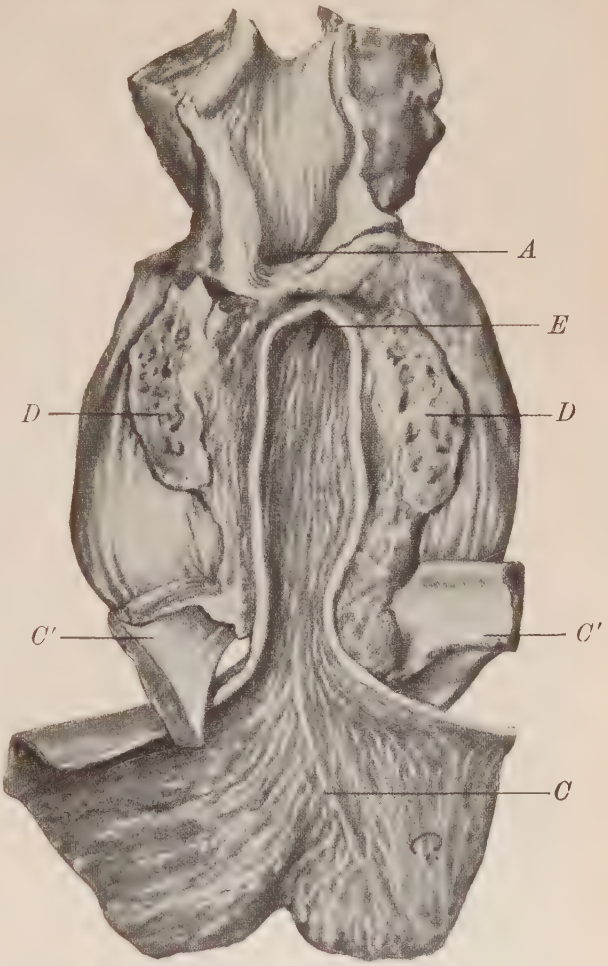


Fig. 219.—Posterior View of Specimen in Fig. 218.

A. Blind end of upper portion of gullet.
C′. Diaphragm.
C. Stomach.
D. Lungs.
E. Abnormal orifice connecting trachea and gullet.

INJURIES OF THE ESOPHAGUS

Wounds of the esophagus may be produced from without—incised, stab, and gunshot wounds—or from within—wounds caused by swallowing sharp or rough foreign bodies, or by the introduction of instruments into the esophagus for diagnostic purposes or for the extraction of foreign bodies. Some of the signs and symptoms of wounds and injuries of the esophagus have been briefly referred to under Injuries of the Neck in General. Here they will be

considered somewhat more in detail. The incised wounds of the esophagus in the neck, as already noted, are regularly associated with injuries of the larynx and trachea, and frequently with injuries of important blood vessels and nerves. The wounds being open to inspection, the diagnosis presents, as a rule, no difficulties. In stab and gunshot wounds, on the other hand, the depth and direction of the wound canal can only be inferred, and the presence of a wound of the esophagus may not be recognized in the absence of the escape of food, etc., from the wound, pain on swallowing, or vomiting of blood. In these cases the formation of an abscess or a phlegmonous inflammation of the neck, and the operative measures for its relief, may first disclose the injury to the gullet. Stab wounds are more often associated with injuries of the large vessels than are incised wounds. Gunshot wounds of the esophagus are often complicated by dangerous bleeding, and, in the case of wounds made by rifle bullets, by fatal injury of the vertebræ and spinal cord.

An unusual case of gunshot wound of the neck which opened the esophagus came under my observation. The patient was a robust negro man, who was shot with a .32 caliber pistol. The bullet entered the neck just at the border of the jaw and one and one half inch to the right of the median line, and ranged downward and to the left. He fell unconscious, but soon recovered himself and was brought to the hospital. The bleeding was insignificant. The patient complained of pain on swallowing. By two X-ray pictures, one of which is here reproduced, the flattened bullet was located resting upon the front of the transverse processes of the fifth and sixth cervical vertebræ on the left side of the neck. On the third day evidences of wound infection were present; on the fourth day tracheotomy was done for the relief of threatening asphyxia caused by edema laryngis; the bullet was then sought for on the left side of the neck and removed. During the search it was found that the esophagus had been opened by the bullet along the left border, and that the escape of food into the tissues had caused the infection. No wound of the air passages was found. The esophagus was sutured, and the external wound was partly closed and drained. No further leakage took place, but the patient's recovery was

FIG. 220.—X-RAY PICTURE OF BULLET WOUND OF THE ESOPHAGUS DESCRIBED IN THE TEXT. (Author's collection.)

delayed by the suppurative inflammation beneath the deltoid muscle, requiring incision. Complete recovery followed.

When the wound involves both trachea and gullet, or larynx and gullet, the wounding of the gullet is often indicated by the entrance of food into the air passages and sudden attacks of choking, coughing, and dyspnea. When the esophagus and trachea are both completely divided by an incised wound, marked retraction of the divided ends takes place downward—notably of the esophagus—so that the end of the lower portion may be drawn below the level of the sternum. Wounds of the esophagus and larynx or trachea may be followed by a fistula, involving one or both canals. The diagnosis of the fistulæ is simple: there is an escape of food and mucus through the external orifice. If the larynx or trachea are involved an air fistula is present, and cicatricial contraction may force these patients to wear a tracheotomy tube permanently. Wounds of the intrathoracic portion of the gullet are much more apt to be followed by mediastinitis, pleuritis, pericarditis, and fatal sepsis than those at a higher level. These injuries are usually associated with fatal lesions of the heart, lungs, trachea, great vessels, etc. The symptoms pointing definitely to injury of the esophagus are pain in swallowing and the escape of food from the wound; there is often extreme thirst; there may be hiccough. Strictures of the esophagus are said not to follow wounds of that canal. The septic infection is accompanied by symptoms which vary somewhat according to whether the associated injuries involve the lung, the pleura, pericardium, etc. Injuries of the air passages are indicated by subcutaneous emphysema, cough, hemoptysis, escape of air from the wound, and dyspnea. Further discussion of the topic will be found under Injuries of the Thorax. The end result of these cases is usually death from shock, hemorrhage, or septic complications.

RUPTURES AND PERFORATIONS OF THE ESOPHAGUS

Spontaneous rupture of the esophagus is an exceedingly rare accident; the few reported cases have occurred during violent retching or vomiting, or from violent shocks to the body—jumping down from a height, for example. It is believed that in nearly all cases the wall of the canal has been weakened by some pathological process. The rupture is nearly always longitudinal, and occurs just above the diaphragm. The pleuræ may also be opened. The symptoms are sudden violent pain, referred to the epigastric region and back—a sensation that something has given way; the patient usually passes, almost immediately, into collapse. There is the appearance of subcutaneous emphysema at the root of the neck from gas which escapes from the stomach into the mediastinum, and finds its way upward. Severe pain, dyspnea, a rapid, feeble pulse, cyanosis, suppression of urine, extreme thirst, hiccough, and death in less than forty-eight hours.

Perforation of the esophagus associated with disease of the canal may occur from without or from within. The accident may occur as a sudden rupture in

cases of stricture during efforts to swallow food, or as an ulcerative process in cases of cancer, tuberculosis, cauterization with alkalies, carbolic acid, etc., or in other forms of ulceration. If the perforation takes place suddenly the symptoms are those of rupture. The results are phlegmonous mediastinitis, empyema, putrid bronchitis, septic pneumonia, pericarditis, gangrene of the lung, according to the site of the perforation. In most instances the perforation takes place more gradually, and to the original condition there are added sepsis, and the signs and symptoms of the lesions just named. Perforations from without occur as the result of malignant tumors of the neighboring organs, from acute or chronic suppurative processes near the esophagus, from tuberculous abscesses of the bodies of the vertebræ, tuberculous or suppurating bronchial glands; an aneurism of the aorta or other large vessel may rupture into the esophagus, as may also an abscess of the lung or an empyema. A rupture of an aneurism, of course, results in immediately fatal hemorrhage. Bleeding from the esophagus cannot always be differentiated from gastric hemorrhage; much, if not all, of the blood usually finds its way into the stomach, and may be subsequently vomited. The general symptoms will be those of internal hemorrhage. If a stricture exists below the seat of the bleeding the blood will find its way into the pharynx and be coughed up.

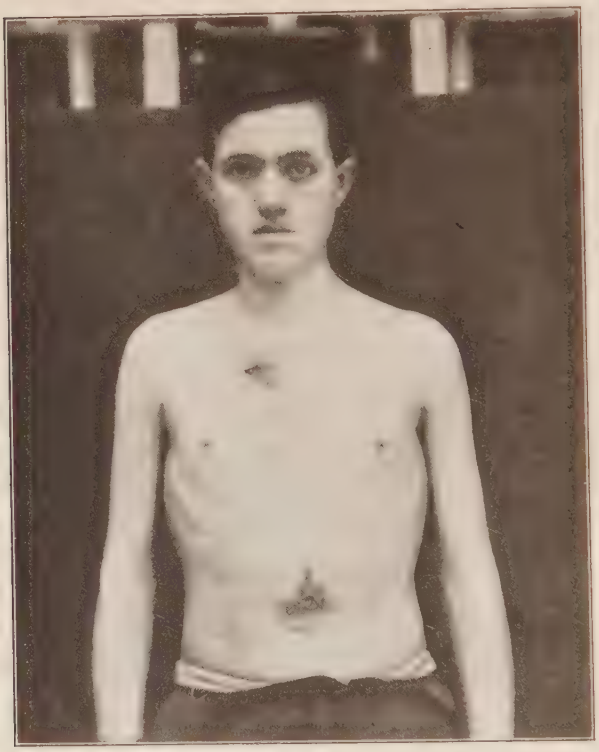


FIG. 221.—DR. DOWNES'S CASE OF ESOPHAGEAL FISTULA. This man reentered the hospital in my service in the autumn of 1908, more than three years after the formation of an artificial opening into the stomach. There was very little discharge from the esophageal fistula and the patient was able to swallow food through the normal channels quite well. He had, however, failed greatly in health. The gastrostomy leaked quite badly. The patient was weak and emaciated. Dr. Downes did an operation for the closure of the artificial opening into the stomach, but the patient was so weak that he did not survive this comparatively slight operation.

The slowly formed perforations from other causes are not always immediately fatal; more or less completely walled-off pus cavities may be formed in the mediastinum, and slowly increase in size and burrow in various directions, occasionally perforating the chest wall. The following unusual case came under my observation. (See illus-

tration.) A man presented himself for treatment with a tuberculous ulcer on the left border of the sternum, opposite the fourth costal cartilage, which seemed to communicate with the posterior surface of the sternum and discharged a good deal of tuberculous material. A scraping operation caused no improvement in his condition, and he passed out of my care. Gradually thereafter he failed in general health and became septic. Later he came under the care of Dr. William A. Downes, who found a large tuberculous cavity in the mediastinum, from which, after a time, food was discharged, thus demonstrating an esophageal fistula. A gastrostomy relieved his condition greatly so that the cavity nearly or quite healed, and the opening in the esophagus closed. There were never symptoms of esophageal obstruction.

FIG. 222.—AUTHOR'S CASE OF ESOPHAGEAL FISTULA. Esophageal fistula in a little girl, due to tuberculous ulceration of a mediastinal gland into the esophagus, and the formation of a sacculated empyema, which I opened by removing a portion of the third rib in front. As soon as the child began to swallow food a portion of it escaped from the drainage opening, thus establishing the diagnosis. The child subsequently died of a generalized tubercular peritonitis and exhaustion.

Another case came under my observation in 1907. (See illustration.) A female child ten years of age was brought to the hospital much emaciated, and suffering from chronic sepsis; she was said to have been ill for three months. Pneumonia had been the diagnosis made; upon examining her it was found that she had the signs of fluid in the upper part of her right chest, anteriorly. A needle introduced below the clavicle in the second intercostal space withdrew pus. Resection of the third rib opened a purulent collection in the right pleural cavity of considerable size. From the opening there escaped after the operation most of the solid and liquid food swallowed by the child. Efforts to pass instruments by the esophageal fistula into the stomach failed. The child continued to fail slowly. A gastrostomy was done, in the hope that her nutrition might be improved; upon opening the belly, extensive tuberculous peritonitis was discovered; abundant food was given through the gastrostomy opening, but the patient gradually faded away, and died some few weeks later.

FOREIGN BODIES IN THE ESOPHAGUS

Only those foreign bodies which become impacted in the gullet are of serious consequence; if they reach the stomach they are usually, but not always, passed *per rectum* without difficulty. The bodies usually gain an entrance through the mouth. The commonest articles to become impacted are plates of false teeth and pieces of bone. In addition to these the list is almost endless, and includes articles hard and soft, smooth and rough, angular and sharp, organic and inorganic, in endless variety, swallowed by accident or design. Children and lunatics form a pretty large contingent of these cases, and occasionally professional jugglers. In cases of stricture, paralysis, or dilatation of the esophagus, or when the esophagus is sharply bent or pressed upon by a deformity or the presence of a tumor or aneurism, bodies which ordinarily would find their way easily into the stomach may become lodged.

There are three situations corresponding to the physiological narrow places of the gullet in which foreign bodies are apt to stop: they are: (1) The upper end of the gullet, at the level of the cricoid cartilage; (2) at the level of the bifurcation of the trachea, or a little higher, opposite the level of the bony girdle of the superior orifice of the thorax; (3) at the level of the diaphragm.

1. Large, soft masses, such as pieces of meat, potato, etc., are apt to lodge in the upper end of the gullet, as already noted under Foreign Bodies in the Larynx. Large, hard, or irregular and sharp or angular bodies also frequently lodge in this situation, and the same is indeed true of slender, pointed bodies—needles, pins, sharp bones, and sticks of wood. These latter, as they are grasped by the muscles—whether they be included in a bolus of food or naked—are often pressed into the mucous membrane by the first muscular movement of the act of swallowing. When a large, hard body is impacted at one of the lower levels, it is frequently because it has been pushed downward during unsuccessful efforts to remove it.

2. Such bodies as pass the upper end of the gullet are most apt to lodge at the level of the entrance to the thorax or opposite the bifurcation of the trachea.

3. The spontaneous lodgment at the level of the diaphragm is exceptional under normal conditions of the esophagus.

The symptoms produced by the lodgment of foreign bodies vary according to the size and other physical characters of the body, and according to the point of lodgment. They are partly obstructive, partly due to pressure, and partly to injury of the wall of the gullet or surrounding structures. The effects, moreover, are immediate and remote. If the body fills the upper end of the gullet and presses upon the larynx, there will be a choking sensation, sometimes severe dyspnea and cyanosis, involuntary efforts to swallow, and retching. The diagnosis in such cases is not difficult; a finger introduced into the upper end of the gullet through the mouth will detect the body.

The X-ray picture (Fig. 216, page 601) shows a fifty-cent silver piece lodged in the esophagus of a boy aged ten, who swallowed the coin accidentally. No symptoms were noted except inability to swallow solid food. As shown, the coin lodged opposite the upper border of the sternum.

During efforts to extract it the coin passed into the stomach and remained in the cardia, as shown by the illustration. After waiting ten days I removed it by gastrotomy. The boy made an uneventful recovery. If the body is sharp and not large enough to occlude the gullet, there will be pain in the throat, increased by swallowing, and felt at a fixed point. If the body has passed below the upper end of the gullet, the pain is usually referred to the sternum, and if the body has passed on, but has wounded the gullet in its passage, such pain may be felt for several days. Attempts to swallow fluids or solids will be followed by success or by more or less complete regurgitation, according to the degree of obstruction. If the gullet is wounded there will be more or less bleeding. Often fluids and soft solids can be swallowed, while solid substances fail to pass (see Figs. 216 and 223).

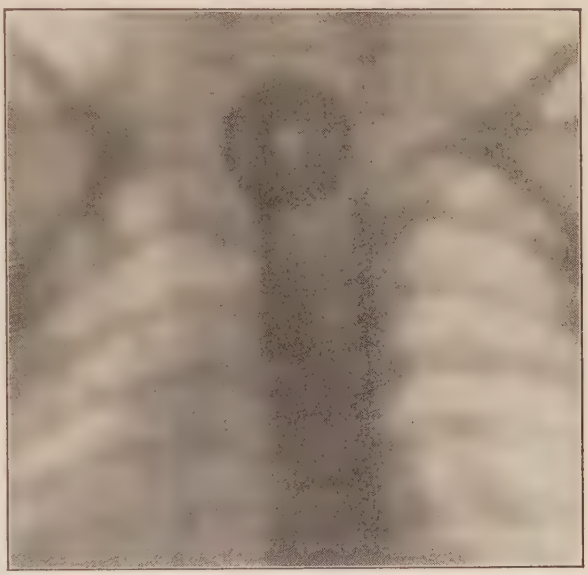


Fig. 223.—X-ray Picture of a Tin Whistle Impacted in the Esophagus of a Boy Aged Six. Under a general anesthetic I was able to extract the whistle with a coin-catcher without much difficulty.

The ultimate results of the impaction of hard substances in the gullet are very varied. They may remain quiescent for an indefinite time, and even be forgotten. Slender, sharp bodies (needles) may perforate the wall of the gullet and travel to distant parts of the body, finally appearing under the integument. In the New York State Hospital for the Insane, at Utica, a woman was admitted who had been a seamstress; during her stay in the hospital there appeared under the skin of her trunk and limbs sewing needles of various sizes; these needles to the number of several hundred were extracted from time to time. It was believed that the needles had been swallowed before her entrance to the hospital. Rough, angular, and sharp bodies ordinarily cause pressure necrosis of the wall of the gullet; such ulceration may be long delayed. The results are various. The body may finally perforate the wall of any of the large vessels and cause fatal bleeding; such bleeding is often preceded by slight

hemorrhages. The presence of ulceration may be inferred from pain and a bloody, purulent discharge, coughed or vomited up from time to time. Perforation into the trachea or a bronchus is followed by putrid bronchitis or septic pneumonia. Perforation into the mediastinum by phlegmonous inflammation. There may also occur phlegmonous inflammation of the esophagus itself, pericarditis, emphysema, pyopneumothorax, perichondritis of the larynx, etc.

The diagnosis of the presence of a foreign body can often be made readily from the history and the symptoms, as already described. It is, however, most desirable that the presence and situation of the body should be demonstrated. There is sometimes a doubt in the mind of both surgeon and patient unless the body is passed *per rectum*, because a body which wounds the mucous membrane may leave behind pain and soreness for some days. If the body is in the pharynx or upper end of the gullet, it can usually be felt with the forefinger or seen in the laryngoscopic mirror. If it is large and hard and in the cervical portion of the gullet, it can often be felt by external palpation of the neck, usually upon the left side. The sensation given to the surgeon's fingers may be slight or doubtful, but the patient will complain of distinct tenderness over a fixed point. If the body has already caused ulceration and inflammatory infiltration of the surrounding tissues, these lesions will give their own easily recognizable signs and symptoms—pain, tenderness, swelling, induration, sometimes emphysema, and the general symptoms of sepsis. If it is metallic, it can be located by the X-rays. Examination with a full-sized graduated bougie or bulbous bougie, with an olive-shaped tip, will usually detect an obstruction if the body is low down. If, however, such a body is not so situated as to materially narrow the canal, and is coated with mucus, the bougie may pass it and the surgeon may believe the body has gone into the stomach. The greatest care and gentleness should be used in the examination of these cases, lest damage be done to the gullet.

In examining with a graduated bulbous bougie, the bulb of metal or ivory will give to the surgeon's hand a grating sensation, or the like, when a hard foreign body is touched; a sound, even, may be audible. The surgeon should be careful that he does not mistake the sound or sensation caused by the shaft of the instrument striking the teeth for that produced by a body in the gullet. The teeth may be covered by a pad of gauze. When the body is thus located its distance from the teeth should be noted on the shaft of the instrument. A very certain method of examination is by the use of the esophagoscope. The body may thus be seen and obstacles to its removal appreciated and sometimes overcome. If the body is small the tube should be withdrawn very slowly, lest the body escape observation by the intervention of a fold of mucous membrane. Hyperemia, wounds, abrasions, ulcerations caused by the foreign body, may also be detected.

DISEASES OF THE ESOPHAGUS

Acute and Chronic Catarrhal Inflammations of the Esophagus.—Acute and chronic catarrhal inflammations of the esophagus are neither of them of much surgical interest. Acute catarrh results from mechanical, thermal, chemical irritation of the mucous membrane; is characterized by hyperemia and an increased discharge of mucus. The patient suffers some pain on swallowing food. The lesions can be recognized through the esophagoscope. Chronic catarrh is common among drunkards, and may accompany benign or malignant stricture of the gullet as well as dilatation and diverticula. It may accompany diseases of the heart and cirrhosis of the liver. The mucous membrane is thickened; there is an increased secretion of mucus. Necrotic and diphtheritic inflammations of the gullet occur as the result of trauma, as complications of acute infectious diseases, and from an extension of a diphtheritic inflammation of the pharynx. They are interesting because they may give rise to stricture.

Phlegmonous Inflammation of the Gullet.—Phlegmonous inflammation of the gullet begins in the submucous tissue. It may be localized or diffuse. The condition is a rare one. It may follow internal trauma from a foreign body or occur as an extension from a similar process in the stomach or the perforation of the esophagus from without by purulent foci in the vicinity. If such a focus breaks at the same time into the trachea, a fistulous communication between trachea and gullet may be formed. There appears to be but little tendency for purulent inflammation originating in the submucous tissue of the gullet to perforate into the mediastinum, pleura, etc. Usually pus forms between the mucous and the muscular coat and, perforating the mucous membrane, empties into the esophagus itself.

Symptoms.—The condition, uncomplicated by the presence of a foreign body, is not itself very easy to recognize. The patients suffer from dysphagia, pain referred to the sternum and back, constitutional depression and fever, sometimes nausea and vomiting. If the abscess breaks into the gullet, there may be cough and expectoration or vomiting of pus. If the process could be diagnosticated it might be possible to incise a localized abscess through the esophagoscope. In the case of an impacted foreign body this has been done by v. Hacker, with a favorable result.

Cauterizations of the Esophagus by Corrosive Liquids.—When swallowed by accident or design, the caustic alkalies and acids cause a violent inflammation of the esophagus. The associated injuries of the mouth, larynx, and stomach are often so severe as to produce death from shock, from the specific action of the poison, from perforation of the stomach or esophagus with resulting peritonitis or mediastinitis, etc. The history, the characteristic burns of the mucous membrane of the mouth and pharynx, the appearance of the eschars, the odor (carbolic acid), the intense pain, vomiting, and constitutional symptoms, render the diagnosis easy. The condition is interesting from a surgical point of view in those milder cases where the patient survives, the sloughs

separate, and cicatricial contraction follows with the production of a stricture of the gullet. (See Stricture of the Esophagus.)

Syphilitic Ulceration of the Esophagus.—Syphilitic ulceration of the esophagus is rare. Most cases occur as a gummatous infiltration and ulceration of the lower part of the pharynx and upper part of the gullet, giving rise to characteristic symptoms and signs which are recognizable on inspection. Upon healing they may cause stricture. In the absence of confirmatory signs elsewhere it would be difficult to discriminate between syphilitic and other forms of ulceration of the esophagus at its deeper portions except through the administration of iodid of potash and the use of the esophagoscope.

Tubercular Ulceration of the Esophagus.—Tubercular ulceration of the esophagus is a rare condition. The cases mentioned under Perforations of the Gullet might properly be classed as a tuberculous invasion of the esophagus from without, arising probably from a tuberculous bronchial gland. Superficial and deep tubercular ulcerations of the gullet have been described associated with other tubercular lesions and tubercular ulcerations of the upper end of the gullet associated with tuberculous ulceration of the pharynx. The symptoms may be marked dysphagia and pain, or in some cases symptoms have been wanting.

Peptic Ulcer of the Esophagus.—Round or peptic ulcer occurs only at the lower end of the gullet, near the cardia. It is a rare condition, supposed to be due to causes similar to those producing ulcer of the stomach. The symptoms also are similar—pain and vomiting of blood. If the ulcer perforates, mediastinitis, empyema, gangrene of the lung, pyopneumothorax, etc., may follow; if it heals, stricture or pocketing of the esophagus. The diagnosis with the esophagoscope would be possible.

Stricture of the Esophagus.—Obstruction of the esophagus may be produced by lesions of the wall of the gullet itself, *internal causes*, or by pressure from without, *external causes*. The strictures produced by internal causes may be divided into *inflammatory and cicatricial strictures*, such as follow the ingestion of caustic alkalies and acids, or ulcerations due to syphilis, peptic ulcer, or ulceration from the pressure of a foreign body, or phlegmonous esophagitis; strictures due to malignant growths (carcinoma), spasmodic stricture, and congenital stricture.

Obstruction of the gullet may also be produced by the presence of a foreign body in the esophageal canal, by diverticula, and by polypoid or other benign tumors which obstruct its lumen without producing a true narrowing of its caliber. Of the true strictures, by far the most frequent causes are cicatricial contraction following the ingestion of caustic alkalies and acids, and carcinoma of the gullet, the latter being more frequent. Those produced by syphilis, ulceration from pressure of a foreign body, are rare. Stricture from peptic ulcer is exceedingly rare. The cicatricial strictures following cauterizations occur most commonly at the three physiological narrow places already mentioned. The same is true of malignant strictures.

Cicatricial strictures may be valvelike or membranous, annular or tubular, according to the depth and superficial extent of the destructive process preceding their formation. The esophagus above the level of the stricture is often dilated. According to V. v. Hacker, the narrowest cicatricial strictures occur at the lower portion of the gullet. When the destructive process has involved the entire thickness of the gullet and periesophageal adhesions have formed, there may occur angular deviations in the direction of the tube. In these cases a false passage is easily made by the incautious introduction of a bougie. In some cases the gullet at the entrance to the stricture or in the course of a tubular stricture may be softened or ulcerated, and in these situations also false passages are easily produced.

Spasmodic strictures, with the exception noted under Cardiospasm, occur in neurotic, usually hysterical, individuals. Congenital strictures are rare. They have been occasionally observed at autopsy as valvelike, membranous projections of the mucous membrane of the gullet in individuals who have given a history of difficulty in swallowing. The *external causes* of obstruction of the gullet are acute inflammatory infiltration or abscess in the surrounding parts, masses of lymph nodes, often tubercular or due to Hodgkin's disease; new growths, of the thyroid or other structures in the neck, especially those which are malignant, mediastinal growths, aneurisms, especially of the arch of the aorta, and deformities of the spine.

Symptoms.—The most prominent symptom of all strictures is difficulty in swallowing food. If the obstruction occurs suddenly, there may be total inability to swallow. If the obstruction is high up, the effort to swallow is followed by immediate regurgitation through the nose and mouth. If lower down, an interval may elapse before regurgitation occurs. If the obstruction is slowly formed the symptoms gradually increase in severity. Cases of cicatricial stricture following the ingestion of caustics are at first of an acute inflammatory character. The obstruction may be more or less marked; efforts to swallow are attended by severe pain. As the acute inflammation subsides the symptoms of obstruction may entirely pass away, to be followed by gradually increasing difficulty in swallowing which may not appear for many months, and is not attended by pain. Fluids and soft solids are usually most easily swallowed, and these patients learn to chew their food very thoroughly, to eat very slowly, and to swallow small quantities at a time. Dilatation above the stricture often occurs, and food accumulates in the dilated part; a catarrhal condition is then established, with frequent regurgitation of foamy fluid mixed with food and of thick, stringy mucus, *causing much annoyance. The material regurgitated contains no free hydrochloric acid.* The position of the stricture may be accurately located by the patient or not. For example, he may locate it at the root of the neck when in reality it is much lower down. As the obstruction increases the nutrition begins to suffer, and a severe grade of emaciation and anemia is finally reached, ending in death from starvation unless relief is afforded.

Spasmodic Strictures of Nervous Origin.—Spasmodic strictures of nervous origin are characterized in most instances by variability in the degree of obstruction which is at times absolute and at times slight or absent. There are usually present marked symptoms of a neurotic or hysterical habitus. The spasm has usually appeared suddenly. Profound disturbances of nutrition are rare, but have been reported in a few cases. I have recently seen a case in a highly neurotic young man, who informs me that he has eaten no solid food for three years. He is fairly nourished, and a full sized bougie passes readily enough into the stomach after the spasm at the upper end of the gullet has been overcome by gentle pressure. A special form of spasmodic stricture was described by v. Mikulicz under the name of Cardiospasm. The condition is attended by a spasmodic closure of the cardiac end of the esophagus, such that food does not properly pass into the stomach. Eccentric hypertrophy and dilation of the lower portion of the esophagus follows, with retention and decomposition of food, and chronic inflammation of the gullet. The quantity of food retained in the gullet may amount to as much as half a liter. The disease occurs during middle and advanced life, and ends, if unrelieved, in death from inanition. In some instances carcinoma of the gullet has developed and ended life. The differential diagnosis from carcinoma can only be made, according to v. Mikulicz, by the esophagoscope. It could readily be made through a gastrotomy wound.

Diagnosis.—The most important aid in the diagnosis of the presence, seat, and caliber of a stricture is examination with esophageal bougies. One selects a cylindrical bougie of full size, or even a soft-rubber stomach-tube, or a good-sized olivary bougie, such as would pass in a normal gullet; by this means the depth of the stricture is determined, and certain possible errors are avoided. A slender instrument might be caught in a fold of mucous membrane or in a valvelike stricture, or a pocket, while a larger one might pass. After the depth of the stricture has been determined, instruments of smaller caliber are introduced until one is found which enters or passes the stricture. Usually when the instrument has entered the stricture it will be firmly grasped by the cicatricial tissue, and although its further progress is possible, it will be with a distinct sense of resistance that the bougie is moved either onward or withdrawn. When the obstruction of the esophagus is due to the pressure of enlarged glands, a mediastinal tumor, or other external cause, the instrument may enter the narrowed portion with difficulty, but once it has passed the obstruction, its further progress or withdrawal is not opposed. According to v. Hacker, in such cases a soft-rubber stomach-tube may pass more easily than a firm instrument. In passing an instrument through a narrow, tortuous, or eccentrically placed stricture, notably when the gullet is dilated above, a good deal of patience may be necessary to engage the point of the instrument in the orifice. In such cases the bougie is withdrawn a little, then advanced, rotated gently, inclined to one wall of the gullet or the other, etc. The surgeon thus learns the peculiarities of that particular case.

If an olivary instrument is used the length of the strictured portion may sometimes be determined. The olive once it has passed the stricture moves easily back and forth. Upon withdrawal, the stricture will grasp the shoulder of the olive and offer a resistance throughout a greater or less distance. If there be several strictures, it will be impossible to determine the caliber of the lower ones, unless they be narrower than those above or until the upper ones have been dilated. If a solid bougie can be moved more or less freely from side to side above the stricture, a dilatation of the gullet is probably present.

Differential Diagnosis Between Cicatricial and Malignant Stricture of the Esophagus.—Differential diagnosis between cicatricial and malignant stricture may be arrived at from a variety of data. We may properly consider here the clinical history of carcinoma of the esophagus. The disease occurs in advanced life, is rare before the fortieth year; more than half the cases occur after fifty years of life; men are more often affected than women in the proportion of three or four to one. The flat epithelial-celled cancer is the common type; cylinder-celled and other forms are rare. The physiological narrowings are favorite sites. In most cases the tumor originates in the gullet, occasionally as an extension from cancer of surrounding structures. The relative frequency of the disease in different portions of the gullet is as follows: Opposite the bifurcation of the trachea, at the level of the diaphragm at the cardia, in the neck, in the order given. The tumor may be small or massive, a portion of the caliber only may be the seat of the disease in its early stages, usually the entire circumference of the tube is cancerous. Secondary tumors often form in the lymph nodes at the root of the neck and in the mediastinum. True metastases may occur in the liver. The duration of life may be less than a year from the first symptoms or may be as long as two years. The symptoms are gradually increasing difficulty in swallowing; pain, a common but not invariable symptom; emaciation, which is progressive, ending in cachexia and death from inanition, or from other causes; among them perforation into the pleura, followed by septic or putrid pleuritis; into the trachea, with septic pneumonia, putrid bronchitis, or gangrene of the lung; into the aorta, or other great vessel, with death from hemorrhage; septic

Fig. 224.—Cancer of the Esophagus, Showing Dilatation of the Gullet above the Stricture. Perforation of the gullet which caused a putrid mediastinitis from which the patient died. The point of stricture is at *A*. (New York Hospital, Pathological Department.)

thrombosis of a vein and pyemia. The dysphagia is progressive. Solid food, soft solids, and finally fluids, are swallowed with difficulty, and are regurgitated at once, if the stricture is high up; after an interval, if lower down. With the food thick mucus is regurgitated in quantity, sooner or later streaked with blood, indicating ulceration. The regurgitation may occur quietly and without effort, or be accompanied by retching. When ulceration occurs, particles of tumor tissue may be brought up; such ulceration may be accompanied by sloughing of tumor tissue, and a temporary increase in the caliber of the gullet with improvement in the dysphagia and in the general condition. Commonly the ulceration is accompanied by putrefactive changes and a fetid breath.

Pain.—In some cases pain or discomfort may be felt before obstructive symptoms are manifest. The pain may be of a dull or of a sharp, tearing character. It is increased by swallowing, during which severe spasmodic pain may occur. The pain may be referred to the back, or to the root of the neck, or may be felt in the back of the neck and radiate into the shoulders. It is sometimes felt at night. In some cases pain is absent, and in no case is it a symptom of great diagnostic value.

Emaciation and Weakness.—Emaciation occurs early in the disease as well as loss of strength, and is usually more rapid than is the case with cicatricial strictures. When the tumor ulcerates there is added chronic sepsis with an evening rise of temperature. When the tumor has infiltrated the surrounding tissues there may be symptoms of pressure on the cervical sympathetic, usually on the left side, drooping of the eyelid, smallness of the pupil, which reacts but slowly to light, and retraction of the globe. Pressure on or involvement of the recurrent nerves may cause more or less severe dyspnea, as may also involvement of or pressure upon the lower end of the trachea or the left bronchus. In making a diagnosis, the age of the patient, if over forty; absence of a history of chemical or mechanical trauma; absence of the signs of aortic aneurism; the frequency of the disease in males; the history of progressive dysphagia; emaciation and loss of strength—strongly favor a malignant growth. Syphilitic strictures are rare. They are usually situated in the upper part of the gullet. A history of infection may be obtained. Their progress is slower; ulceration, if present, usually heals under large doses of iodid, the subsequent history being that of cicatricial stricture. Enlargement of lymph nodes at the root of the neck is absent.

Physical Examination.—A tumor or thickening of the gullet can only be felt if the cancer is above the sternum. Enlarged hard glands at the root of the neck in conjunction with symptoms of progressive obstruction favors a malignant growth. Examination with bougies: Usually a bougie of suitable size will detect an obstruction more or less marked. Exceptions are cases in which the tumor does not surround the gullet; cases in which sloughing of the tumor has occurred. Some bleeding often follows even the most gentle introduction of the bougie, and if a hollow bougie with a lateral eye is used, fragments of tumor tissue may be brought away. Under the microscope these may

confirm the diagnosis. By means of direct examination through the esophagoscope, the differential diagnosis between cicatricial and malignant stricture is possible. The white areas and bands of scar tissue are very different in appearance from the infiltrated, ulcerated surfaces of cancer. The raw surface is covered by vascular granulations, which bleed freely and readily, or with foul necrotic tissue. In cases of cancer it is usually possible to nip off a bit of tissue by means of a suitable forceps for microscopic examination, thus establishing a positive diagnosis at once.

Spasmodic stricture in the upper portion of the gullet can usually be overcome by gentle, patient effort with a full-sized bougie. If necessary, the patient may be anesthetized. Cardiospasm can best be recognized, according to v. Mikulicz, through the esophagoscope. Pressure upon and even true stricture of the gullet may be caused by tuberculous glands situated near the bifurcation of the trachea, forming adhesions to or rupturing into the gullet. The condition might be recognized by other evidences of tuberculosis and the esophagoscope. New growths of the thyroid as a cause of obstruction are easily recognized if malignant. Mediastinal tumors and aneurism as a cause of obstruction must be recognized by their physical signs or by the X-rays. It is to be remembered that tumors do not cause obstruction unless they surround or infiltrate the gullet. In old people, thickening and hardening of the posterior portion of the cricoid cartilage may give rise to difficulty in swallowing. It is to be recognized by digital examination of the pharynx, by laryngoscopic examination, and by the passage of bougies.

Dilatations of the Esophagus.—Dilatations of the esophagus occur above strictures, whether cicatricial or malignant, as well as in cases of cardiospasm. They are to be recognized by the symptoms mentioned under cardiospasm—namely, regurgitation of undigested food and catarrh of the gullet. Further, by the extraordinary mobility of instruments in the dilated portion and the difficulty of reaching the stomach. A positive diagnosis of the exact condition can be arrived at only through the esophagoscope. As already suggested in regard to diverticula, an X-ray picture taken after the patient has swallowed a quantity of bismuth emulsion would be a useful aid in the diagnosis. The following procedure was proposed by Rumpel as a means of differentiation between diffuse dilatation of the esophagus and diverticulum: A tube is introduced into the stomach. This tube is perforated laterally here and there, a second tube is introduced into the dilated portion of the gullet, colored fluid is then injected into this second tube. If the fluid returns by the tube in the stomach, a dilatation is present; if only by the second tube, a diverticulum.

Diverticula of the Esophagus.—A localized distention of the gullet with the gradual formation of a sac of greater or less extent, lined by mucous membrane and blind at its distal end, is known as a diverticulum. Zenker divided these pouches into two groups, according to their causation: Diverticula arising by pressure from within, "pulsion diverticula"; diverticula arising from traction upon the gullet from without, "traction diverticula." They may

further be divided for purposes of description into those occurring in the upper and lower parts of the esophagus respectively. Diverticula are rare conditions.

Pulsion Diverticula of the Upper Portion of the Esophagus.—These occur more often in men than in women. They rarely cause symptoms until middle life or later. The bulging of the wall of the gullet usually begins on the posterior wall and a little to the left of the middle line, and in this type is always opposite the level of the cricoid cartilage. It has been found that in this situation the longitudinal muscular bundles are thinner than elsewhere, and it is assumed that the occurrence of a bulging at this point is favored by frequent gagging, vomiting, and perhaps by other causes — i. e., trauma. The sac varies in size from a pouch as large as the end of one's finger to a cylindrical or pear-shaped sac many inches in length, which may extend into the thorax. The pouch is lined by mucous membrane, which may be eroded or ulcerated from prolonged irritation and pressure from its contents of decomposing food. A more or less complete investment of muscular fibers surrounds the sac. The pouch usually forms on the left side and hangs down alongside of or behind the gullet a variable distance. The orifice in the gullet may be as large as, larger or smaller than, the caliber of the gullet itself.

Usually no symptoms are produced until the pouch has reached a considerable size, so that food is retained in it. As a further increase takes place, the pressure of the distended sac tends to keep the normal orifice of the gullet closed, thus producing dysphagia. The symptoms are slowly developed. They vary in different cases. The patient usually has some difficulty in swallowing hard, soft, or liquid food, as the case may be. He has a sensation of pressure and discomfort in the neck while eating and after. He may learn to eat slowly and with the head in a certain position, or to make certain movements while eating; or to press with his finger upon some fixed point in the neck during the act of swallowing. Sometimes the first few mouthfuls are swallowed with difficulty, later food goes down readily. Sometimes the condition is reversed. He suffers from regurgitation of considerable quantities of mucus into the pharynx. He vomits after eating; this vomiting may be simply a regurgitation of small quantities of unchanged food accomplished without much effort, or there may be quite violent gagging and retching; in either case relief follows. Meanwhile the appetite remains good, the patient has no real gastric distress.

After a time observation may show that the vomited matters consist of fragments of food eaten several days before; such material has a stinking, putrid odor, contains lactic acid, but no hydrochloric acid. The patient's breath becomes offensive. The time may come when the food distends the sac and compresses the gullet in such a manner that no food enters the stomach. By external pressure in the neck the patient may be able to empty the sac partly or wholly, or by drinking water and throwing it up again he may wash its

contents out, and when it is emptied small quantities of food may reach the stomach. When this stage is reached serious disturbances of nutrition occur. Sometimes the putrid contents of the sac are regurgitated and swallowed again; if a portion reaches the stomach, indigestion, fermentative changes, vomiting, diarrhea, flatulence, toxemia are added to the other symptoms. With such a history the diagnosis of a diverticulum is rendered probable. A physical examination shows the presence of a swelling in the neck in about half the cases, and manipulation and pressure upon the swelling forces its contents into the pharynx.

Examination with bougies may give valuable information. When the sac is full the bougie will usually enter it rather than the gullet. The bougie passes a certain distance easily and stops. The end remains freely movable. The bougie may sometimes be felt in the neck, usually to the left of the middle line. A subsequent attempt to pass the bougie into the stomach may succeed. If the bougie once enters the true route to the stomach it passes easily without obstruction. If the bougie lies in the bottom of the diverticulum, it must be withdrawn the entire length of the sac before it can engage in the orifice of the gullet leading to the stomach. If the passage of the bougie were opposed by a mere fold of mucus membrane, by a symmetrical dilatation (ectasia), or by a tortuous canal through a stricture, a slight withdrawal and subsequent advance might suffice to overcome the difficulty. These characteristics serve to distinguish the condition from strictures, malignant or benign. When the diverticulum is well developed, it often happens that the direct route downward from the pharynx leads into the sac, while the opening of the esophagus is a mere slit or small orifice on its anterior wall; under such conditions it is necessary that the sac should be emptied before a bougie can be made to pass into the stomach. In the effort to enter the esophagus with a bougie the instrument should be passed into the back of the pharynx and the patient told to swallow; the esophageal opening may then for an instant become patent, and the bougie may find its orifice. The differential diagnosis between dilatation and a diverticulum by means of two tubes, one in the stomach, the other in the diverticulum or dilatation, has already been mentioned. By causing the patient to swallow bismuth emulsion the situation and extent of a diverticulum might be made out by its skiagraphic shadow.

Deep-seated Diverticula.—Deep-seated diverticula from distention are exceedingly rare; a few only have been described. No tumor is formed in the neck. The patients have a sense of oppression after eating, vomiting, which occurs without nausea after eating, and may be produced voluntarily by closing the larynx and bringing into action the muscles which compress the thorax. There is gradually increasing dysphagia, and finally disturbances of nutrition. The diagnosis can sometimes be made with a bougie having a tip shaped like a catheter coudé (an elbowed catheter). Such an instrument may sometimes be made to enter the stomach or the diverticulum at will by changing the direction of the curved tip. The character of the vomited material is

similar to that already described. The X-rays and the two-tube test with colored fluids may also give information, as already mentioned.

Traction Diverticula.— Traction diverticula have only slight surgical interest, since they seldom produce symptoms *per se*, and are usually discovered at autopsy. They arise for the most part from the anterior wall of the esophagus, opposite the bifurcation of the trachea, and are due to cicatricial contraction of adhesions formed between the wall of the gullet and inflamed or broken-down bronchial glands the seat of tuberculosis or other inflammatory focus. A funnel-shaped pocket may thus be formed in the wall of the gullet, usually of small size, with the apex of the funnel directed upward or to one side, rarely downward. Evidences of a further increase in size by dilatation from within have been observed in a few cases. The surgical interest of the condition is that perforation of the gullet may take place by ulceration from without or by the lodgment and pressure of a foreign body from within. The diagnosis of such a diverticulum might be made through the esophagoscope.

New Growths of the Esophagus.—By far the most frequent and important new growth occurring in the gullet is cancer. The symptoms and diagnosis have already been sufficiently described. Of the other new growths may be mentioned cysts, papilloma, fibroma, myoma, lipoma, sarcoma. They are not common tumors, and with the exception of papilloma and sarcoma, rarely give rise to symptoms. Cases are on record where large papillomata have formed and have caused slight difficulty in swallowing. The papillomata closely resemble cutaneous warts. The diagnosis could be made through the esophagoscope or by the passage of a fenestrated bougie and tearing off a bit of the papillomatous growth for examination. Sarcoma occurs in various forms, and in the situations commonly the seat of cancer—i. e., at the upper end of the gullet and opposite the bifurcation of the trachea. The symptoms are chiefly those of obstruction and of hemorrhage, which may be fatal. Rupture into the trachea is not uncommon in the advanced stages of the disease.

Polypoid Growths of the Esophagus.—Polypoid growths of the esophagus may be fibromata or fibromyomata. They occur most commonly at the upper end of the gullet, and grow from the posterior wall occasionally at lower levels. They are rare tumors. If small, they give no symptoms. If large, symptoms occur. They have been observed in men and women, more often in men, and develop during middle age or later in life. They are usually pedunculated tumors of cylindrical or elongated pear shape, and may reach a considerable size. As they hang down the gullet, swallowing movements tend continually to lengthen the tumor by traction. The symptoms are moderate dysphagia, a sensation of the presence of a foreign body, sometimes a palpable, movable tumor in the neck. If they are coughed up into the pharynx, they may overlie the larynx and cause sudden choking and even asphyxia. Compression does not cause regurgitation of food into the pharynx (difference from diverticula). They may cause vomiting or a desire to vomit after eating. During an act

of vomiting they may be coughed up into the pharynx, and have been observed of such a length that they actually hung out of the patient's mouth. The surface of the tumor is covered with mucous membrane, frequently found excoriated or even ulcerated from the constant mechanical insults to which it is exposed. In those cases where the tumors are not coughed up into the pharynx the diagnosis can be made by means of the esophagoscope. Ordinarily the diagnosis is quite simple, and in cases where the tumor habitually inhabits the pharynx or mouth, can be made on inspection, or by the aid of the laryngoscopic mirror, or by palpation with the forefinger.

CHAPTER XXI

THE THORAX

DEFORMITIES OF THE THORAX

Deformities of the thorax may be congenital or acquired. The more common types are enumerated below.

Congenital Deformities of the Thorax

Deformities of the Sternum.—The sternum may be congenitally absent. The space between the ribs may be occupied by fibrous tissue, or by a thin membranous layer only. The bone may be fissured, the fissure being complete or partial. There may be one or more round or oval holes in the bone. The xiphoid cartilage may be bifid or perforated. But one lateral half of the sternum may be developed. These deformities are of no great surgical interest, and their recognition requires no description. The defects of the sternum may be accompanied by hernia of the lung. Funnel-shaped depression of the lower part of the sternum occurs as a congenital defect of unknown causation and independent of any pathological condition. The deformity may be slight or marked. A typical case is shown in the illustration (see Fig. 225).

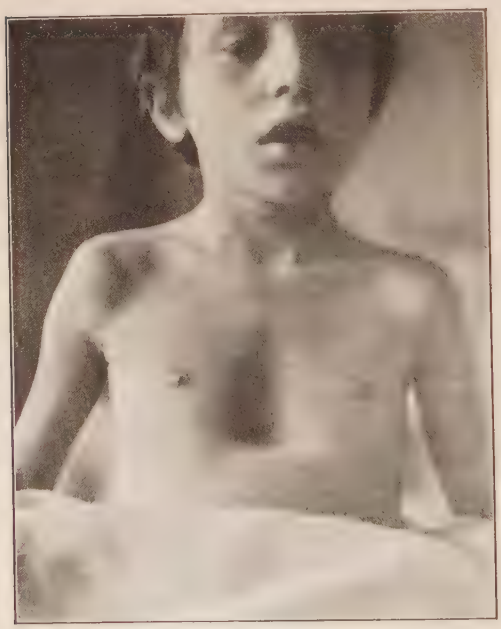


Fig. 225.—A Congenital Deformity of the Sternum, Showing Marked Funnel-Shaped Depression. The countenance of the child is also characteristic of enlarged tonsils and adenoids of the pharynx for which condition he entered the hospital. (New York Hospital collection.)

Congenital Defects of the Ribs.—There may be supernumerary ribs. (See Cervical Rib.) One or more ribs may be wanting or imperfectly developed, ending anteriorly at the axillary line, for exam-

ple. When a rib is wanting, the space is occupied by a more or less dense layer of fibrous tissue. The diagnosis is evident on palpation, sometimes on inspection. If the twelfth rib is wanting, the pleura might be opened in certain incisions used for exposing the kidney. One or more ribs may be fused together or unite to articulate with but one cartilage. (See also Kidney.)

Fig 226.—Deformity of the Thorax Following Empyema. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

Congenital Defects of the Muscles of the Thorax.—Congenital defects of the muscles of the thorax are rare. The most common is absence or imperfect development of the pectoralis major. The clavicular portion is sometimes absent. The pectoralis minor, the serratus magnus, and the intercostal muscles may also be congenitally absent. Such defects may be associated with absence of certain ribs, defects of the sternum, and with imperfect development of the skin and underlying soft parts.

Fig. 227.—Deformity of the Thorax Following Pott's Disease. (New York Hospital Collection.)

Acquired Deformities of the Thorax.—Acquired deformities of the thorax may be the result of injury or of disease. Rachitis, scoliosis, and Pott's disease of the spine, chronic bronchitis and emphysema of the lungs, empyema with collapse of the lung—all give rise to more or less typical deformities, and the same may be said of habitual tight lacing of stays among young women. Rachitic deformity of the thorax is often associated with enlarged tonsils, adenoids of the pharynx, and deformities of the nasal fossa. The deformity is sometimes spoken of as "pigeon

breast" or "chicken breast," "pectus carinatum." The antero-posterior depth of the thorax is increased, the transverse diminished, except at its lower part. (See Rachitis.) The deformity of the thorax accompanying chronic bronchitis and emphysema consists in a general expansion of the thorax by the increase in size of lungs, such that the thorax assumes almost a cylindrical or barrel shape. The deformity is quite common among elderly laboring men who suffer from chronic bronchitis. The acquired deformities accompanying diseases of the spine, etc., are described under their appropriate headings.

Hernia of the Lung.—Prolapse of the lung through openings in the walls of the thorax, the result of trauma, are readily recognizable. If the lung pro-

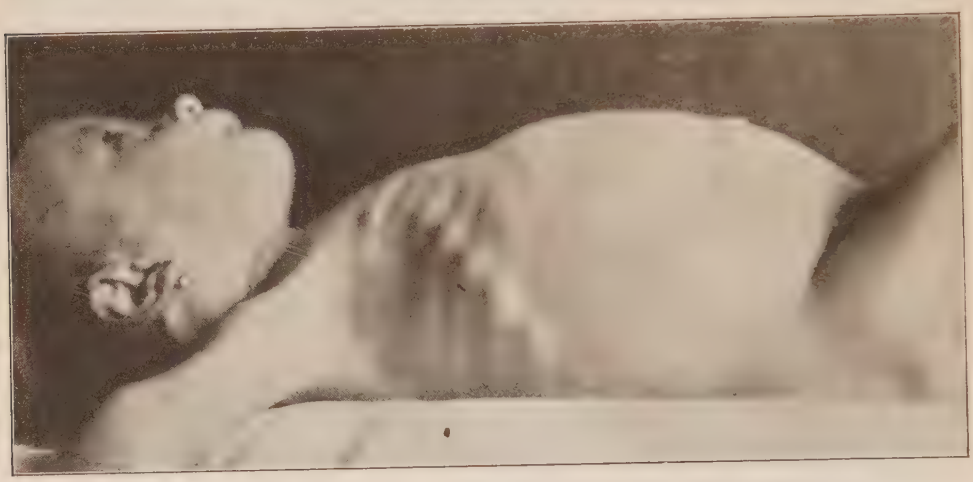


Fig. 228.—Deformity of the Thorax from von Jaksch's Anemia. (New York Hospital Medical service.)

trudes in an open wound, the character of the lung tissue is evident on inspection. Such lung tissue may be normal in appearance if recently prolapsed. If inflamed, it will be covered with a fibrino-purulent exudate and hepatized. If strangulated, it may be gangrenous. If the prolapse is subcutaneous, the tumor is elastic, compressible, can be reduced, with the sensation of an emphysematous crackling, and unless the lung is strangulated, vesicular breathing may be heard over it on auscultation. True hernia of the lung may be congenital or acquired. The congenital herniæ are very rare. The lung may protrude into the neck alongside the trachea, between the ribs at the junction of the ribs with their cartilages, through congenital defects in the sternum. Sometimes as a congenital defect the lung is displaced from its normal situation in part, and protrudes externally or internally, as into the peritoneal cavity. The condition is known as ectopia of the lung, and is distinguished from hernia by the fact that in the latter a normally placed lung protrudes through some normally weak place in the thoracic wall, which has been further weakened by injury or disease. Acquired hernia occurs as the result of chronic bronchitis and emphysema, and from violent spasms of coughing, as

in whooping-cough, etc. The points of protrusion are the root of the neck, at the junction of the ribs with their cartilages, and the intercostal spaces in front of the thorax.

INJURIES OF THE THORAX AND ITS CONTENTS

Subcutaneous Injuries

Contusions of the thorax arise from various kinds of blunt violence; blows, falls, and crushing injuries of all degrees of severity. So long as the soft parts, skin, subcutaneous tissues, and muscles alone are injured, while the wall of the thorax and its contents escape, the signs and symptoms are those of simple contusions merely—namely, pain, soreness, and tenderness, increased by motion if the muscles are injured, together with swelling and ecchymosis due to the presence of extravasated blood. The more serious injuries of the thorax, such as follow "run-over" accidents, falls from a height, being caught between the buffers of railway cars, etc., are commonly attended by fractures of the ribs and the sternum, and injuries of the thoracic contents, the lungs and trachea, the pleura, the heart and great vessels, the diaphragm and esophagus. The injuries to the viscera may be caused by the broken ends of fractured ribs, or the sternum or the viscera may be crushed between the anterior thoracic wall and the spine by simple compression. If the thorax is suddenly and violently compressed while the glottis is closed the lungs may burst. The thoracic viscera withstand slow and gradual compression remarkably well without grave injury. The sudden violent compressions are often associated with similar injuries of the abdominal viscera, rupture of the liver, the stomach, intestine, kidney, spleen.

The organs most commonly injured are the lungs; their laceration is accompanied by bleeding, with the production of hemothorax, hemopneumothorax, pneumothorax, and if the parietal pleura is also torn, by subcutaneous emphysema. In these cases emphysema arises from fracture of ribs and laceration of the pulmonary and parietal pleura. It is easily recognized by the diffuse swelling and the unmistakable subcutaneous crackling on palpation. Emphysema in the tissues of the mediastinum causes symptoms of compression of the heart, lungs, etc., dyspnea, oppression, a rapid heart, etc. Cough with expectoration of foamy blood is a common symptom. Depending upon the gravity of the injury the general symptoms will vary greatly. After slight injuries the general symptoms will be absent or trifling; in severe cases marked shock will be present, a feeble pulse, cold, clammy extremities, dyspnea, cyanosis, or paleness of the face, hurried, superficial, labored or irregular breathing, and orthopnea. A very marked sign present in many of the most severe cases of thoracic compression is a diffused dusky ecchymotic discoloration of the thoracic wall extending upward sometimes on to the neck and face, and in some cases accompanied by ecchymosis into the ocular conjunctiva. Minute punctate hemorrhages

can be seen in the skin over some areas. The appearance somewhat resembles the post-mortem discoloration seen upon the dependent portions of the body some hours after death. The sign indicates a very serious injury. If, in addition to the injury of the lung, the heart and great vessels are crushed or wounded, the condition of shock ends rapidly in death. If the injury to the thoracic viscera is moderate while the abdominal organs are also ruptured, the abdominal symptoms may be most marked.

If the diaphragm is ruptured there will be severe pain and dyspnea with costal respiration. A remarkable case of this kind is shown in the illustration, a drawing made at the autopsy of a man who had died some hours after a crushing injury of the thorax. He was brought to the Hudson Street Hospital in a condition of shock, from which he did not rally. The stomach and a considerable portion of intestine were found as shown in the pleural cavity,

Fig. 229.—Rupture of the Diaphragm, Prolapse of the Stomach and a Portion of the Intestine into the Pleural Cavity. (Hudson Street Hospital.) (Drawing by Dr. B. S. Barringer.)

where they had found their way through the ruptured diaphragm. The condition was not suspected during life. Cases of this kind have survived for long periods, the condition only being recognized at autopsy. In other cases death has followed the introduction of an aspirating needle into the hollow abdominal viscera, contained in the thorax, for purposes of exploration, the physical signs being those of pneumothorax. The degree of subcutaneous emphysema, common enough in cases of extensive rupture of the lung and

pleura, is well shown in the accompanying illustration of a man who was crushed in an elevator shaft, both lungs were ruptured and several ribs fractured; his body showed the peculiar discoloration already mentioned. He lived several days, suffering from shock, cyanosis, and dyspnea, with bloody expectoration. The emphysema continually increased. The photograph was made about four hours before death.

Fig. 230. — Subcutaneous Emphysema from Fracture of Several Ribs, Rupture of Both Lungs. (Author's collection.)

Physical Signs.—Pneumothorax, hemothorax, hemopneumothorax, and their combination, give the physical signs of these conditions—namely, the affected side of the chest is enlarged and is more or less completely immobile. The heart impulse is displaced. Vocal fremitus is greatly diminished or abolished. Percussion over the affected side usually gives a high-pitched tympanic note, very rarely flatness or dullness. If blood be also present, as is usually the case, there will be flatness or dullness up to the level of the fluid; by changing the position of the patient this dullness may change its position. On auscultation there is absence of breathing, or very feeble breathing over the affected side; the respiratory sounds on the uninjured side are loud and exaggerated. On coughing or taking a deep breath the sound known as metallic tinkle may be present; the voice often has a peculiar metallic quality. The coin sound is sometimes present. It is elicited in the following manner: The surgeon places his ear on the patient's thorax posteriorly while an assistant holds a coin on the skin of the front of the chest and strikes it with another coin. A characteristic metallic echoing sound is thus produced, which is unmistakable. In the presence of fluid the succussion or splashing sounds may be heard by placing the ear against the thorax and shaking the patient. This sound may sometimes be heard by the patient himself, or be audible to bystanders. The abdominal viscera may be displaced downward, so that the upper border of liver dullness is displaced even as low as the costal margin in front.

Subphrenic Pneumothorax and Subphrenic Pyopneumothorax.—An accumulation of gas or of gas and pus between the liver and the diaphragm may simulate true pneumothorax. Such a collection may form as the result of traumatic or pathological perforation of the hollow viscera of the abdomen, or might accompany a subphrenic abscess from any cause if gasogenic bacteria were present in the exudate. It will rarely happen in traumatic cases that the condition simulates a pneumothorax so closely as to lead to diagnostic error. The signs of peritonitis—pain, abdominal rigidity, vomiting, etc.—together with the history of the injury, will usually point definitely to an abdominal origin. The differential points are as follows: History of an abdominal injury or disease, absence of cough, expectoration, and dyspnea; absence of marked displacement of the heart; the presence of normal or nearly normal breathing; voice and vocal fremitus over the upper portion of the thorax. A sharp line of demarcation above, between the normal lung resonance and the tympanitic resonance below, normally occupied by liver dullness; marked displacement of the liver downward. Over the tympanitic area below; absence of voice and vocal fremitus. (For furtlier discussion, see Diseases of the Abdomen.) In using an aspirating needle for the determination of the presence of blood or pus in the pleural cavity, it is to be borne in mind that serous or purulent fluid and fluid blood can readily be drawn through a needle of moderate size. This is not true of clotted blood, which can only be drawn through a very large needle or trocar, and that with difficulty, if at all, except through a powerful steam or compressed-air exhaust pump. A little may be obtained usually as a plug in the interior of the needle, and may suffice for a diagnosis. It is further to be remembered that a needle thrust into the lung may enter a vein, and thus create a possible error in diagnosis. The subcutaneous injuries of the lung are only rarely followed by pneumonia or by empyema.

FIG. 231. — DEFORMITY OF THE THORAX FOLLOWING EMPYEMA. (New York Hospital, service of L. A. Stimson.)

Commotio thoracica—Concussion of the Thorax.—Under this title are described certain cases of sudden compression of the thorax, attended by the

symptoms of shock, sometimes immediately fatal, in which no lesions of the thoracic viscera are found to account for the symptoms. The condition has been accounted for in various ways—irritation of the pneumogastrics, paralysis of the sympathetic, and compression of the heart. The symptoms are those of shock; there is a marked fall of blood-pressure; coldness and paleness of the surface of the body; sometimes unconsciousness; shallow respiration. Death may take place at once. In case of survival, the patients recover quite rapidly—in minutes, hours, or a day or two. The signs and symptoms of lesions of the viscera are absent. It is probable that in many fatal cases lesions were present but unrecognized.

Wounds of the Thorax

Wounds of the thorax may be divided into penetrating and nonpenetrating.

Nonpenetrating Wounds.—Nonpenetrating wounds of the thoracic wall may be incised, stab, punctured, lacerated, and gunshot wounds. They are rarely serious injuries unless infected. Serious hemorrhage is only likely to occur from injury of the internal mammary or intercostal arteries. The diagnosis of incised or contused and lacerated wounds is to be made by inspection. The diagnosis of nonpenetrating stab and punctured wounds is to be made from the history of the injury, the character of the weapon producing it, the presence or absence of bleeding, or the formation of a hematoma, and the absence of the signs and symptoms of injury of the thoracic viscera.

Gunshot Wounds of the Wall of the Thorax.—A bullet moving at a low velocity may produce a mere contusion of the skin and subcutaneous tissues. It may penetrate but a short distance and remain palpable under the skin, it may strike a rib or the sternum and cause a fracture without penetrating; such a fracture may wound the pleura and lung. The probable diagnosis of a nonpenetrating wound can often be made from the absence of symptoms. One or more X-ray pictures may aid in the diagnosis. A peculiar class of gunshot wounds are those in which the bullet strikes the chest wall and is deflected by a fascial layer, a tendon, or a bone, and travels a greater or less distance along the chest wall without penetrating, to emerge or lodge at a point perhaps opposite to the point of entrance, giving the impression that it has passed through the chest. Signs and symptoms of injury to the viscera are absent. In the absence of bleeding, infection, or other indication for interference, such wounds had better be let alone; nothing is to be gained by exploration, and much harm may be done. If exploration becomes necessary, the upper extremity should be placed in the position it occupied when the shot was received; thus the track of the bullet may be more easily followed.

Wounds of Vessels.—*The Internal Mammary Artery.*—The internal mammary artery may be wounded in stab and gunshot wounds. The injury is often associated with wounds of the pericardium, heart, pleura, and lung. According to the character of the external wound the bleeding may take place

externally or into the mediastinum, pleura, or pericardium, causing symptoms of dyspnea, disturbances of the pulse from compression of the heart, the signs of hemorrhage, etc. The artery runs downward parallel with and close to the border of the sternum from the third intercostal space to the level of the sixth or seventh costal cartilages, where it divides into its terminal branches to the anterior abdominal wall and the diaphragm. It is usually accompanied by two veins. If the bleeding is external, the diagnosis is to be made from the anatomical site of the wound and the occurrence of rapid arterial hemorrhage. Statistics of uncomplicated wounds of the internal mammary treated by a double ligation show a mortality of over ten per cent. In untreated cases the mortality has been very high.

Wounds of the Intercostal Arteries.—Wounds of the intercostal arteries, though not as dangerous as those of the internal mammary, may yet be serious or fatal injuries. Stab and gunshot wounds are the most frequent causes, fractures of ribs being rarely accompanied by bleeding from these vessels. The intercostals are often wounded during excision of portions of ribs, but here the control of the bleeding is a simple matter.

Wounds of the Pleura and Lung.—In stab and gunshot wounds, injury of the pleura and lung are common. The bleeding may take place externally, or into the pleura, or both. If externally, it will be brisk arterial bleeding. If the pleura or pleura and lung are also wounded, the blood may be mixed with air, and escape only during expiration, the blood and air being sucked into the pleura during inspiration. Emphysema may be present around the wound. If the bleeding occurs into the pleural cavity, there will be signs of hemo- or hemopneumothorax, dyspnea, and the symptoms of hemorrhage. Such bleeding may, of course, come from a wounded lung. If there is reason to suspect, from the character and situation of the wound, that dangerous hemorrhage is going on from an intercostal artery, the diagnosis should be confirmed by enlarging the wound, resecting a rib, if necessary, in order that a ligature may be properly applied to the vessel.

Penetrating Wounds of the Thorax.—Penetrating wounds of the thorax may involve the pleura, the lung, the pericardium and heart, the great vessels, the trachea and esophagus, and the diaphragm. Wounds of the costal pleura alone occur from fractured ribs. If uncomplicated, the injury is rarely attended by any symptoms other than pain, cough, and a little dry pleurisy, which may be recognized by fine friction râles heard on auscultation over the injury. The occurrence of subcutaneous emphysema over a simple fracture of a rib indicates an injury of the lung. Open wounds of the thorax may be incised, stab or gunshot wounds; less commonly they are lacerated wounds; these latter are commonly caused by great degrees of violence; such have been caused by a blow of the paw of a powerful wild beast—a bear, a lion, tiger, etc.—or from crushing injuries. Penetrating wounds involving the costal pleura alone are less common than wounds both of the pleura and lung. In some cases it may be impossible to tell whether the lung is wounded or not. The presence of

cough with bloody or rusty sputum indicates that the lung has been wounded. Wounds at the lower limits of the pleural cavity may open the pleura without injuring the lung. The following figures indicate the positions of the border of the lung and of the limit of the pleural sac in different parts of the chest during quiet breathing. It will thus be seen that a considerable space exists between the edge of the lung and the bottom of the costophrenic sinus; the space is greatest in the axillary line.

The table is a personal communication from Prof. George S. Huntington.

	Sternal line.	Parasternal line	Mammillary line.	Axillary line.	Costovertebral line.
Level of lower border of lung	Upper border of sixth rib	Lower border of sixth rib	Upper border of seventh rib	Lower border of seventh rib	Eleventh rib
Lower limit of pleura	Upper border of seventh rib	Middle of seventh rib	Lower border of seventh rib	Ninth rib	Twelfth rib
Difference in vertical height between lung and pleura	2 centimeters	2 centimeters	2 centimeters	6 centimeters	2.5 centimeters

Wounds of the Pleura.—Wounds which penetrate the pleura in a tangential or oblique direction are less likely to penetrate the lung than those which penetrate at right angles. When the pleura is opened, air enters the pleural cavity in greater or less quantity, according to the size and shape of the opening. If the opening is free, much air enters, the lung collapses completely, and ceases to functionate. Adhesions between the lung and parietal pleura prevent its collapse to a variable extent. If the wound canal is small or oblique, no air may enter from without. When the pleura is filled with air, that side of the chest is distended, and the heart and the other lung are compressed.

The *symptoms* produced by complete sudden collapse of the lung vary in gravity in different cases: some patients show intense dyspnea, orthopnea (the breathing is largely diaphragmatic), cyanosis; have a rapid, thready pulse. The physical signs are immobility and distention of the chest on the injured side. Tympanitic resonance over that side of the chest and absence of breathing or very feeble respiratory sounds on auscultation (pneumothorax). The condition may end in death, from failure of the heart or respiration. The symptoms are likely to be more severe when the pneumothorax is on the right side. The entrance of air through an open wound takes place during inspiration, and is accompanied by a loud blowing or whistling sound. During expiration some air escapes, but less than has entered during inspiration. If the wound remains open, air continues to enter until the lung is completely collapsed. If the wound is large, and especially if it be near the border of the

lung, prolapse of lung tissue may take place during expiration. If both pleural sacs are opened and both lungs collapse immediate death occurs. It is worth remembering that in cases of large abscess in the right lobe of the liver, when pressure and infiltration hold the right half of the diaphragm nearly or quite

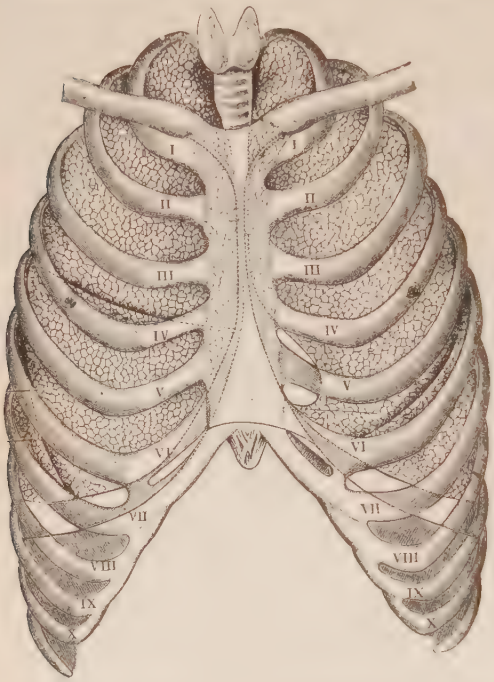


FIG. 232. — SHOWING THE RELATIONS OF THE LUNGS AND OF THE LOWER LIMIT OF THE PLEURA TO THE RIBS. Thorax viewed from in front. (After Merkel.)

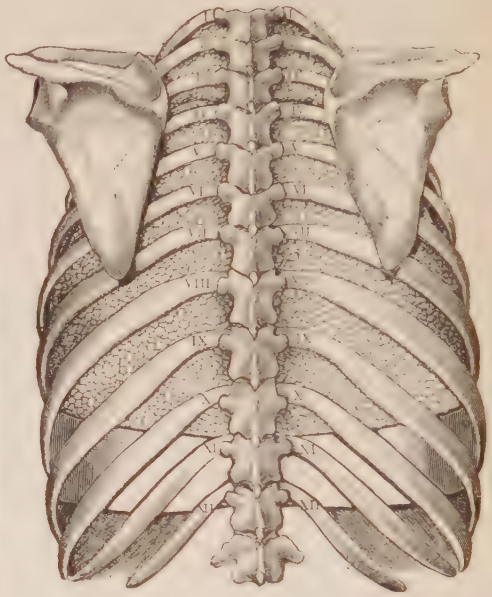


FIG. 233. - SHOWING THE RELATIONS OF THE LUNGS AND OF THE LOWER LIMIT OF THE PLEURA TO THE RIBS. Thorax viewed from behind. (After Merkel.)

immobile, the pleural sac may be entered in the axillary line, for the purpose of evacuating the liver abscess, with scarcely any risk of creating a pneumothorax. The pressure of the abscess holds the costal and the diaphragmatic pleurae quite firmly in contact below the border of the lung, so that the surfaces remain in contact when the pleura is opened without the aid of sutures, even though no inflammatory exudate is present on the pleural surfaces. The symptoms of collapse of one lung are not always grave. During operations the pleura is often opened by design, sometimes by accident. The symptoms may be slight and temporary. It is true that in empyema the affected lung is already partly deprived of its function, and that in accidental wounds of the pleura during operations the surgeon usually succeeds in closing or plugging the opening before complete collapse of the lung has occurred. If no infection takes place, and no dangerous amount of bleeding occurs into the pleura and the wound is closed, the subsequent history of pneumothorax is usually favorable; the air and even blood may be quite rapidly absorbed. In a day or two the lung may begin to expand and resume its functions. A long

delay or the accumulation of much blood in the pleura points to a wound of the lung; often to a wound of a bronchus. In these cases the collapsed condition of the lung may be more or less permanent, and that without serious impairment of health.

Infection of Wounds of the Pleura.—Infection of wounds of the pleura occurs from stab and incised wounds made with unclean instruments, and is especially common when an infected foreign body remains in the wound, a splinter of wood, a portion of a knife blade or dagger, an arrowhead, a bullet, or a portion of clothing. As stated under gunshot wounds, many bullet wounds of pleura and lung run an aseptic course. Infection is further favored by accumulation of blood in the pleura; it may be pyogenic, putrefactive, or both. The general symptoms are those of sepsis or pyemia. Locally, a rapid exudation takes place into the pleural sac. The patient suffers from dyspnea, and a rapid, feeble heart. The thorax on the affected side is distended; the intercostal depressions are obliterated; the chest on that side does not take part in the respiratory movements. If the exudate is large in amount, the heart is displaced toward the other side, and the sound lung is compressed. There is flatness on percussion up to the level of the fluid, absence of voice and breathing on auscultation, and absence of vocal fremitus (empyema). If air and pus are present, the signs are the same as those described under hemopneumothorax. The introduction of an aspirating needle into the thorax below the level of the fluid withdraws pus or broken-down and putrid blood clot, as the case may be. Unrelieved by suitable drainage, these cases end in death from sepsis, with heart and respiratory failure from compression, or pyemia.

Wounds of the Lung.—Gunshot and stab wounds are the common forms of wounds of the lung. Much less common are impalement on stakes, pickets, etc., in falls from a height, arrow wounds, contused and lacerated wounds from crushing injuries, or from portions of exploded shell in battle. The gravity of wounds of the lung depends chiefly on two things—hemorrhage and infection. The diagnosis is often entirely simple; rarely very difficult. Positive signs of wounds of the lung are, in the presence of a wound of the thoracic wall, cough, and bloody, usually foamy, expectoration, a nearly positive sign, but absent in a certain proportion of even severe injuries, and the escape of a foamy blood from the external wound. The cough is usually frequent, harassing, and painful; the patient strives to suppress it all he can. In addition there may be present pneumothorax, or pneumohemothorax, air rushing in and out of the external wound, emphysema of the chest wall in the neighborhood of the wound, especially of the external wound, is small or oblique, so that a valve-like closure of the pleura prevents the entrance of air from without. Very extensive emphysema also speaks for a wound of the lung. If the lung is adherent to the chest wall at the wounded area, there may be no pneumothorax, but very extensive emphysema, which may spread over the entire body in a few hours. If such emphysema extends into the mediastinum, it may cause fatal dyspnea from compression of the viscera.

I saw a case of this kind during the time when I was acting as interne in Bellevue Hospital. A man was brought to the hospital who had been stabbed in the right axilla. There were no signs of dangerous external or internal bleeding, nor of marked hemo- or pneumothorax, but a rapidly progressive subcutaneous emphysema, which involved almost his entire body in a few hours, and reached enormous proportions. As the emphysema grew more and more marked at the root of the neck he began to suffer more and more from dyspnea and oppression in breathing, gradually his heart failed, and he died in forty-eight hours from the time of receiving the wound. At the autopsy a moderate amount of air and blood were found in the right pleura; there was a fairly deep stab wound of the right lung. The subcutaneous tissues throughout the body were emphysematous, and the distention of the loose tissues of the mediastinum with air was especially marked. Particles of foreign material may be coughed up—shreds of clothing, for example—after gunshot wounds. Dyspnea, which may be severe, moderate, or not noticeable, depending largely upon the presence or absence of pneumothorax and upon the amount of bleeding into the pleura or into the trachea. The nearer the wound is to the root of the lung, the more likely the occurrence of fatal bleeding. When a large vessel at the root of the lung is wounded, the blood may fill the trachea and cause immediate death from asphyxia or severe dyspnea with profuse hemoptysis, which may continue until death, or recur at intervals with a finally fatal result. The symptoms of internal bleeding into the pleura are coldness and paleness of the face and extremities, sometimes cyanosis, marked dyspnea, and a sense of oppression, thirst, convulsions, a rapid, feeble pulse, finally syncope, dilated pupils, and death. Nearly all wounds of the lung are accompanied by some bleeding into the pleura unless the lung is adherent to the thoracic wall at the point of wounding. But in gunshot wounds, especially, pneumothorax is often slight, unless a bronchus is wounded.

A boy, aged ten, was accidentally shot in the thorax with a .32 caliber pistol. The bullet entered in the posterior axillary line in the sixth intercostal space and ranged inward, wounded a large vessel at the root of the lung and one of the primary bronchi. He ran a few paces and fell. He was found in a condition of shock, suffering from severe dyspnea and profuse hemoptysis; in fifteen minutes he was dead. In other cases, if the wound involves no large vessel and infection is absent, the symptoms may be slight. A man walked into Bellevue Hospital in apparent good health. He stated that he had been shot in the left breast the preceding night with a .32 caliber pistol. Examination showed a bullet wound in the second intercostal space in the midclavicular line on the left side. There was no wound of exit. There was slight emphysema in the immediate vicinity of the wound. He complained of a painful cough, which he endeavored to suppress. His sputum was foamy and blood-stained. Physical examination showed normal resonance everywhere over the chest except a small area of dullness beneath the wound. Auscultation showed diminished breathing over the same area, elsewhere normal. There were dry

pleuritic friction râles over the upper lobe of the left lung in front. He developed no further symptoms, and left the hospital in ten days quite well. In recent wars fought with small-caliber rifles it has been observed that while many wounds of the lung are immediately fatal from internal hemorrhage, those in which no large vessel is divided nor large bronchus opened get well in many instances without very serious symptoms. If not probed, the wound usually remains aseptic. Wounds from the small-calibered rifles are often perforating and pursue a straight course through the tissues, so that a wound of the lung can often be inferred on anatomical grounds alone. The prognosis in these cases is, other things being equal, rather better than in cases of lodgment, since sometimes such a bullet may be the center of a focus of infection which does not declare itself for some time. The characters and effects of bullet wounds from various kinds of weapons have been described in the chapter on Gunshot Wounds. The small-caliber rifle bullet does not produce very destructive effects upon lung tissue; the track of the bullet is small and clean, unless the bullet is deformed by ricochet or strikes sideways. Hemoptysis is usually present, but moderate. Emphysema may be absent or slight, and is usually confined to the vicinity of the wound. The orifices are so small that air does not enter the pleura from without. Hemothorax is usually moderate. In some cases the bleeding has continued slowly for several days or has recurred at intervals, notably in those cases where the patients had to be moved about under unfavorable conditions. In direct shots, foreign bodies are rarely carried into the wound, and if the wounds are not explored, infection is the exception. Associated injuries, especially of vessels, of course, change the prognosis for the worse. The location of bullets in the cavity of the thorax is generally practicable by means of the X-rays. Their removal is, however, another matter.

Infection of Wounds of the Lung.—Infection of wounds of the lung occurs for the most part through the wound in the thoracic wall, very rarely through the inspired air in the lung itself. Infection is caused by bacteria introduced into the wound at the time of the injury by the weapon or missile or by a foreign body driven into the tissues—a button, a portion of clothing, of a leather strap worn across the shoulder, etc.—or is introduced afterwards by manipulations with unclean fingers or instruments or unclean materials applied to the wound. Infection is favored by much contusion and laceration of tissue of the thorax or of the lung itself such as occurs in some gunshot wounds, notably those produced by a soft-lead rifle bullet, or by a bullet which fractures a rib and drives fragments of bone into the lung. The results of such infection may be suppuration merely of the external wound, more commonly empyema, purulent or putrid septic pneumonia, abscess of the lung, gangrene of the lung. An abscess of the lung or an empyema may perforate in various directions outward through the thoracic wall, into the lung or a bronchus, into one of the great vessels, downward into the abdomen, producing an abscess or a purulent peritonitis, or more rarely into the stomach or intestine. The signs and symp-

toms of empyema have already been described. The diagnosis of septic pneumonia rests upon the presence of the signs of a lobular pneumonia, rapid breathing and pulse, pain, cough, mucopurulent sputum, together with the general symptoms of sepsis. The diagnosis of abscess of the lung rests upon the presence of similar signs and symptoms, together with the expectoration of large quantities of pus, sometimes containing blood and fragments of lung tissue. The diagnosis of gangrene of the lung is to be made from the signs and symptoms of an area of consolidation in the lung, the general symptoms of sepsis together with cough and the expectoration of a purulent or bloody sputum having a horrible, putrid odor, and sometimes containing black fragments of gangrenous lung tissue. The breath also is stinking and fetid to a degree. For the details of diagnosis of these conditions the reader is referred to Surgical Diseases of the Lungs. The occurrence of infection is to be inferred from the advent of fever of a septic type. Moderate fever is commonly present in cases of hemothorax, though they remain aseptic. (See Aseptic Wound Fever.) Dyspnea, increase of pain and cough, prostration, a rapid pulse, a rapid increase of the fluid exudate in the pleura indicate infection. The presence of pus or putrid blood clot in the pleura can usually be demonstrated with an aspirating needle thrust into the cavity below the level of the fluid. In ordinary cases the needle may be introduced in the back in the seventh or eighth intercostal spaces or in the axillary line between the fifth and sixth ribs. It is not wise to choose the very bottom of the pleural cavity for the point of insertion, since the diaphragm or the abdominal viscera might be wounded. If the exudate is encapsulated or if an abscess of the lung is suspected, the needle is introduced wherever the physical signs are most marked. The following histories illustrate the course of an infected gunshot wound of the lung, and of another which remained clean. The second case is interesting on account of the long duration of a pneumothorax.

In the year 1885 A. B., a large, vigorous-looking Swedish man, aged thirty-eight years, who had acute gonorrhea and felt that life under such painful circumstances was no longer desirable, shot himself in the left breast with a .38 caliber pistol. He was seen by a physician, who probed the wound and, for reasons best known to himself, applied to it a portion of chewing tobacco which had already fulfilled its proper function, covering this with a neat bandage. On admission to the hospital, a bullet wound was found in the fourth intercostal space on the left side just external to the nipple: there was no wound of exit. The wound did not bleed; there was no emphysema; the patient did not suffer from shock; there was a painful cough and blood-stained sputum. Examination of the left lung showed the presence of a moderate hemothorax. The condition of the patient remained favorable until the fourth day, when he had a chill, a sharp rise of temperature, gradually increasing dyspnea. The amount of fluid in the left chest rapidly increased. On the tenth day a portion of the sixth rib was excised in the axillary line, the pleura was opened, and a large amount of pus evacuated. The pleura was drained.

Temporary improvement occurred, but the lung did not expand. The amount of purulent discharge from the pleura remained large. The patient gradually failed in strength and became emaciated; a daily rise of temperature occurred. After several months a second operation was done, and other ribs to the number of four were extensively excised. The lung was found almost completely collapsed. Following this operation the patient gradually improved. The right lung greatly increased in size, the left pleural sac became nearly obliterated, and the wound finally healed. The patient left the hospital after many months in good health.

A young man was shot with a .32 caliber revolver in the right chest. The bullet entered the third intercostal space in the midclavicular line. The signs of hemopneumothorax developed with collapse of the lung, though septic symptoms did not develop. The physical signs indicated much fluid in the pleura. Resection of a rib; evacuated a large amount of fluid and clotted blood from the right pleura; lung found collapsed. The external wound healed, but in spite of various measures used to cause the lung to expand, *pneumothorax continued with but little increase in the size of the lung for four months,* when the patient passed out of observation.

Injuries of the Pericardium and Heart.—Isolated injuries of the pericardium are rare; in most cases the heart is also injured, and in many the pleura. The injuries come for the most part from without—incised, stab, and gunshot wounds—but may arise from within, as from a foreign body which ulcerates through the esophagus, a needle which finds its way through the wall of the gullet, and the like. Occasionally the sharp end of a fractured rib may wound the pericardium. The diagnosis of an isolated injury of the pericardium may in rare instances be simple, as when a large incised wound or, even more rarely, a wound from a shotgun or a shell fragment, opens the pericardium and lays the heart bare to inspection or palpation. In many instances it may be difficult or impossible, unless the signs of an exudate of some sort in the pericardium appear.

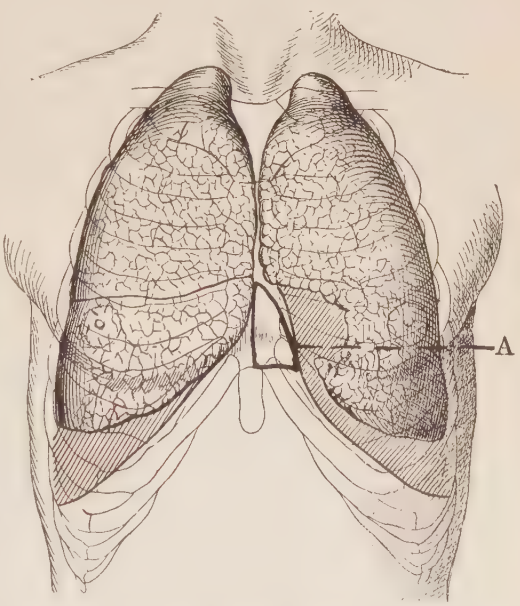


Fig. 234.—Diagram to Show the Relations of the Lung and the Complementary Pleural Space to the Chest Wall. The small triangle A represents the area of the pericardium uncovered by pleura in the average case. (After Merkel.)

That portion of the pericardium which lies in immediate contact with the anterior wall of the thorax uncovered by pleura is of triangular shape. (Be

it understood that these limits vary greatly.) Vertically, this area extends from the level of the junction of the fourth costal cartilage with the sternum downward to the level of the junction of the seventh costal cartilage with the sternum. The middle line of the sternum approximately forms one side of the triangle between these two levels. The long side of the triangle varies in position; in some cases it extends in a line curved to the left downward and outward, and crosses the left border of the sternum about at the level of the fifth costal cartilage, and ends at the level of the seventh costal cartilage or opposite the junction of the body of the sternum with the xiphoid cartilage, and distant from the left border of the sternum 2 cm. in about one fifth of the cases examined. The short side of the triangle is a line which approximates the junction of the body of the sternum with the xiphoid appendix. The extent to which the reflection of the pleura retreats to the left varies a good deal in different cases, so that a wound through a given point might open the pleura in one case and not in another. In some instances the right

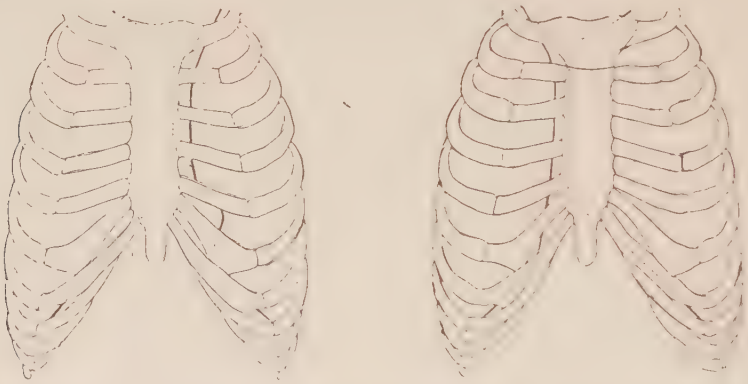


FIG. 235.—REPRESENTS THE MAXIMUM VARIATION IN THE POSITION OF THE ANTERIOR BORDERS OF THE PLEURAL SAC WITH REFERENCE TO THE STERNUM AND RIBS. (After Merkel.)

pleura may even overlap the left behind the sternum. The importance of these relations is, that to explore the pericardium, a needle is sometimes introduced to determine the presence and character of an exudate. In order to avoid the pleura with the greatest degree of probability, the needle may be introduced in the fifth interspace close to the left border of the sternum, or about an inch external to this; either of these points will avoid wounding the internal mammary artery. Fortunately, distention of the pericardium by an exudate pushes the pleura away on either side and increases the area through which a needle may be introduced without injuring the pleura. Such distention can be outlined by the increase in the area of heart dullness. A valuable guide for the introduction of the needle is thus obtained.

Symptoms of Injuries to Pericardium.—The symptoms of wounds of the pericardium vary greatly in different cases. A simple incision or puncture may produce no symptoms or signs, assuming that no infection occurs, except

some acceleration of the pulse rate, a dry friction sound over the pericardium, and some localized dry pleurisy. In healing, adhesions are commonly formed between pericardium and heart. If, on the other hand, hemorrhage takes place into the sac in quantity, very marked symptoms occur. Such bleeding comes not from the pericardium, but from the heart or from the thoracic wall or lung. The action of the heart becomes tumultuous, irregular, rapid, and soon feeble. There is severe dyspnea, and, unless relief is possible, these patients speedily die, the heart being compressed by the effused blood so that it cannot properly expand in diastole. This condition of compression of the heart by effused blood was called by Rose "tamponade" of the heart. The physical signs may be increase of heart dullness and a friction murmur; the heart sounds may be diminished, absent, or normal. If the pleura and lung are also wounded, air may accumulate in the pericardium. The heart dullness will then be absent and replaced by tympanitic resonance. A mixture of air and blood may give rise to splashing sounds on auscultation or to a metallic tinkle. In the presence of hemothorax or pneumohemothorax a wound of the pericardium may pass unrecognized. Infection of wounds of the pericardium gives rise to *purulent pericarditis.* The signs and symptoms resemble those of hemopericardium, with the added general symptoms of sepsis, high fever, sometimes a chill. The purulent exudate compresses the heart. There is rapidly increasing dyspnea, cyanosis, a rapid, irregular, and feeble pulse, ending speedily in death unless operative relief is possible. Some of these cases are combined with infection of the pleura and empyema, or pyopneumothorax. Pericardial effusions tend to accumulate rather behind the heart than in front of it. The heart is believed by some observers to be pressed forward against the chest wall. When introducing an aspirating trocar into the pericardium for diagnostic purposes it is important to avoid puncturing the heart or wounding the coronary artery. A small trocar and cannula is safer than a sharp-pointed aspirating needle, although a long hypodermic needle is safe enough. The trocar is entered at the left border of the sternum in the fifth intercostal space, and pushed slowly and carefully (as previously stated, this point is a safe one, but another may be chosen in the particular case, the guide being the limits and shape of the area of heart dullness; the third, fourth, fifth, and sixth spaces have been successfully utilized by various surgeons) obliquely upward and inward; as soon as the point of the instrument is believed to be in the pericardial sac, the stylet should be withdrawn. Some surgeons recommend precautions against the entrance of air into the pericardium by using a trocar with a lateral opening and stopcock, to which a piece of rubber tube is attached, its end immersed in sterile salt solution. Other surgeons recommend the use of a small aspirating needle, and tie over its outer end a sterile rubber condom. The aspirator of Dr. Potain may be used. Inasmuch as puncture of the pericardium is only made under very grave conditions, and for the relief of pressure upon the heart by serum, pus, blood, air, or a mixture of these materials, and the aspiration can only be regarded as a diagnostic and palliative measure, many surgeons prefer

to resect the cartilage of the fifth rib on the left side, thus gaining access to the pericardium by an opening which permits of subsequent drainage of the sac.

Wounds of the Heart.—Wounds of the heart may be subcutaneous or open wounds. The subcutaneous wounds may be produced by a fragment of a fractured rib or the sternum, or they may be ruptures of the heart from blunt violence, such as occurs from sudden violent compression of the chest. The heart may be wounded by foreign bodies, notably needles which have made their way to the heart from a distance. Such foreign bodies may have been in the body for years before they reached the heart. They may cause serious or fatal symptoms, or in some instances none at all. Sometimes needles and pins or other bodies in the esophagus or trachea may perforate these structures and reach the heart. Traumatic ruptures of the heart may involve any one of its chambers; in addition, the cusps of the valves may be ruptured. The open wounds of the heart are commonly stab or gunshot wounds; less commonly they are incised or contused and lacerated wounds. Wounds of the heart may be superficial or penetrating; the latter open one or more of the heart cavities. The great majority of wounds of the heart enter from in front, much less commonly from the side or rear.

Gunshot wounds of the heart vary in character. Wounds made with the small-calibered rifle bullet will drill a round hole through the heart muscle without much laceration of tissue, or in other cases, if the ball strikes the heart in diastole, the heart may be extensively torn and ruptured. In the case of soft-nosed or express bullets (those with a hollow point), the disintegration of the heart muscle, and even of surrounding structures, is most extensive; the same is true of shotgun wounds at short range. An interesting observation has been made in a number of instances of gunshot wounds of the heart, namely, that the heart may be wounded, even ruptured, and the valves torn by bullets which do not penetrate the pericardium. The effects of wounds of the heart are in a large proportion of cases sudden death. The wounded individual collapses like a steer when struck in the forehead with a poleax. The heart ceases to pulsate; death is immediate. In some cases even a slight wound of the heart is immediately fatal in this way. In a good many cases, even of severe injuries of the heart, life is prolonged for minutes, hours, or days, even for many days, though death finally occurs. A small proportion of cases recover with or without treatment. In those cases which survive for a certain time, symptoms rather varied in character and not very characteristic occur.

The diagnosis is aided by the anatomical site of the wound, the history of the wounding, the character of the weapon, the length of the blade, the direction of the wound canal, etc. There may be little or no bleeding from the external wound, if it be small. If larger, the blood may escape in rhythmic gushes, and be lighter- or darker-colored, according to its source in one or other side of the heart. Such blood may, of course, come from an intercostal, the internal mammary, a coronary artery, or from the lung or one of the great

vessels of the thorax. Many cases of wounds of the heart fall at once into a condition of profound shock, with syncope. If they rally and consciousness is regained, they suffer from profound dyspnea and precordial distress. Bleeding from wounds of the heart may take place externally or into the pericardium or pleura. The expression of the face is anxious, pale or cyanotic, and the forehead bathed in a clammy sweat. The physical signs of hemo- or pneumopericardium may be present, as already described; respiration is extremely rapid, labored, and superficial. The pulse is absent, or rapid and irregular. There may be the symptoms of profuse hemorrhage, thirst, restlessness, convulsions, sometimes vomiting and diarrhea. It sometimes happens that during the feeble heart action which accompanies the original syncope the bleeding from the heart ceases, only to recur after minutes, hours, or even days, with further syncope and death. These cases are not out of danger for a long time. In cases which recover from the immediate effects, serious lesions of the heart muscle, the valves, and the endocardium may remain, and finally end the patient's life. Infection and purulent pericarditis renders the prognosis much worse.

An illustration of the manner in which a wound of the heart may produce but few symptoms at first, and even progress favorably toward apparent recovery for some days, to die quite suddenly, came under my observation some years ago. A large, muscular man of middle age shot himself with suicidal intent, and was brought to the hospital a prisoner. The weapon used was a .22 caliber revolver. There were two wounds, one near the middle of the forehead; the skull was not penetrated, and the bullet could be felt beneath the scalp, flattened against the bone, not far from the wound of entrance. The second wound was in the third intercostal space, a half inch from the left border of the sternum. On admission to the hospital the patient was in moderate shock; there was no bleeding from either wound. He suffered from marked dyspnea and orthopnea. His pulse was rapid, feeble, and irregular. No physical signs pointing directly to a wound of the heart were made out; the heart sounds, though weak, were present. His condition improved in every way during the next twenty-four hours. At the end of this time a slight increase in heart dullness was noted. Examination of lungs negative. He continued to improve until the fifth day, and was then regarded as out of danger. On this day, while sitting up quietly in bed, he suddenly fell back in syncope, and in a moment or two was dead. The autopsy showed a moderate amount of recent blood clot in the pericardium and a little, older blood clot. There was a slitlike wound penetrating the middle of the wall of the right ventricle. This wound was about one half inch in length and contained a recent clot. The bullet was found free in the cavity of the right ventricle.

There is no certain method of recognizing the presence of a foreign body in the heart. After a wound in which a bullet or portion of a weapon remained in the thorax, its presence in the heart might be inferred from the symptoms, and the inference might possibly be confirmed by an X-ray picture.

Ruptures of the heart from blunt violence are usually immediately fatal injuries. The following are the principal mortality statistics of wounds of the heart: Loison found 9 recoveries among 23 cases of needle wounds of the heart, 11 recoveries among 90 cases of stab wounds, 3 recoveries among 110 gunshot wounds. The prognosis of stab wounds of the heart has been improved by recent successful operative treatment. The mortality of stab wounds promptly operated upon has been reduced to somewhere near sixty per cent.

Injuries of the Great Vessels of the Thorax.—The aorta, pulmonary arteries and veins, the superior vena cava, the innominate artery and vein, may be wounded by stab and gunshot wounds, or foreign bodies may ulcerate through the gullet and erode their walls. Some of them may also be perforated by the pressure of a tracheotomy tube, or opened by ulceration from a neighboring purulent focus. Unless the opening is small or incomplete, sudden death from external or internal bleeding results. In other cases death may be delayed for hours or days. If the wound is very small or incomplete, an aneurism may form, and rupture after a variable period with a fatal result. Wounds of these vessels very rarely come under treatment at all.

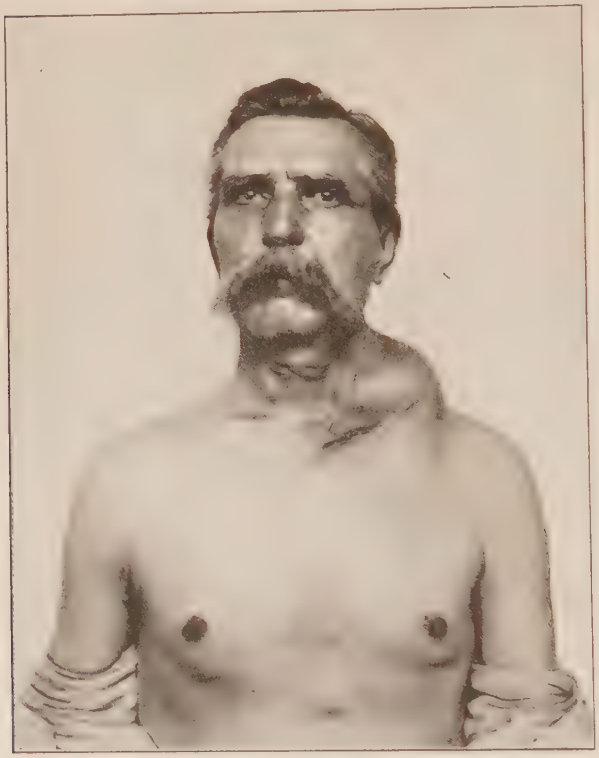


Fig. 236.—Traumatic Aneurism of the Subclavian Artery. (New York Hospital, service of Dr. Frank Hartley.)

Injuries of the Thoracic Duct.—Injuries in the cervical portion have already been mentioned. Injuries in the thoracic portion rarely occur alone, but are usually associated with other and more serious lesions. Simple rupture of the duct may lead to a chylous hydrothorax, i. e., to the accumulation in the pleura of a greater or less quantity of milky fluid, and the physical signs of fluid in the pleural cavity. The character of the fluid is readily recognizable by its gross appearances and the presence of fat droplets under the microscope. Under normal conditions it coagulates spontaneously when exposed to the air. The presence of the injury, when complicated by hemothorax or other serious lesions, cannot be recognized.

Injuries of the Diaphragm.—Subcutaneous rupture of the diaphragm may occur from severe crushing injuries, and instances have been recorded of ruptures as the result of vomiting and during labor. The diaphragm may further be wounded by stab and gunshot wounds of the abdomen and thorax. In most cases of rupture or of wounding, the injury to the diaphragm itself is of less consequence than the associated lesions of the heart and lungs, or of the abdominal organs. Subcutaneous ruptures are sometimes followed by prolapse of the stomach and intestines; sometimes the spleen or a portion of the liver, into the pleural cavity. If much of the contents of the belly lie in the thorax, the former may be retracted while the latter is distended. According to circumstances, marked symptoms may or may not be present. In some cases such herniæ have existed for years unrecognized. In others they have caused early strangulation of the gut and death. In cases of recent prolapse there may be symptoms of compression of the heart and lungs, dyspnea and rapid heart, etc. The physical signs in the chest may be characteristic. There will be tympanitic resonance over the thorax up to a certain level, with absence of voice and breathing; above, there may be normal resonance and feeble or normal breathing. There may be splashing sounds, heard spontaneously or on shaking the patient. If the stomach is in the pleural cavity and an effervescent drink be swallowed—a Seidlitz powder, for example—the area of tympanitic resonance may be increased and bubbling sounds may be heard. The patient may suffer from colicky pain, from dyspepsia; he may vomit. If the gut becomes constricted, there will be the symptoms of intestinal obstruction. If the gut ruptures into the pleura, a putrid pyopneumothorax would speedily develop. Simultaneous wounding of stomach and diaphragm without prolapse may be followed by the escape of stomach contents into the pleura and empyema. Prolapse of lung into the abdomen is rare.

The symptoms referable to the diaphragm itself in cases of rupture or of wounds may be slight or marked. Pain is felt in the region of the diaphragm, made worse by coughing, vomiting, or taking a deep breath; the patient breathes as quietly as possible, spares his diaphragm all he can. The pain may radiate to the shoulder. Severe dyspnea will only be present when there are associated injuries or prolapse of the viscera, as above. Injury of the diaphragm is common in stab and gunshot wounds of the thorax and belly. The existence of such a wound may be inferred, as, for example, when an individual, shot in the thorax, has symptoms referable to the belly—pain, vomiting, rigidity of the abdominal wall, etc. A positive diagnosis can rarely be made without operative exploration.

Fractures and Dislocations

Fracture of the Sternum.—Except as the result of gunshot and stab wounds, this is a rare injury. It is almost unknown in childhood and very rare before adult life. The line of fracture is most often transverse, or nearly so, rarely

oblique, and very rarely longitudinal. The most frequent seat of fracture is at or near the junction of the manubrium with the body of the bone. The manubrium itself may be broken near its lower border. The manubrium may be separated from the body by a fracture or a dislocation, according to whether ankylosis has taken place or not, or the fracture may be through the body near its upper border; less frequent is a fracture of the middle portion of the body, and very rare a fracture or a separation of the ensiform cartilage. If we except gunshot wounds and stabs, fractures of the sternum are nearly always simple; they are usually complete, but in many cases the periosteum of the posterior surface is wholly or partly preserved. They may be produced by external violence or by muscular action. External violence may act directly or indirectly. In the former case the bone is broken by blows or falls upon the chest, by violent compression, as in run-over accidents, compression between railway-car buffers, and the like. In the latter the bone may be broken by extreme bending of the body backward or forward. Falls upon the shoulders or upon the dorsal spine produce the first. The bone is bent backward through its muscular and ligamentous attachments, and more or less torn apart. Falls upon the buttocks and upon the breast, such that the body is forcibly bent forward, produce the second. The fractures by muscular action have occurred during straining in labor and by efforts to lift heavy bodies, notably when the body was bent far backward and the individual was trying to lift a heavy weight by his teeth. The common form of displacement in fractures of the manubrium and of the body is forward displacement of the lower fragment, sometimes with overriding. The upper fragment is rarely in front of the lower.

The diagnosis is usually easy; if displacement exists, a mistake can hardly occur. The patients assume by preference a sitting posture, bend the body forward, and avoid breathing deeply. There is localized pain, increased by motion or by deep breathing, often mobility of the fragments, tenderness at the point of fracture, crepitation unless the fragments override, and usually ecchymosis. This last sign is of especial value, if it appears late, in cases where no deformity is present, but only localized pain and tenderness. Associated injuries may give rise to marked symptoms: rupture of the lung to pneumopericardium and subcutaneous emphysema, or to hemopneumothorax; laceration of the internal mammary artery or veins to hemopericardium or to abundant extravasation into the mediastinum, with pressure symptoms or symptoms of hemorrhage. Associated injuries of the heart and abdominal viscera produce severe symptoms which overshadow those of the fracture. Fractures and dislocations of the ensiform cartilage are attended by the signs of fracture. The deformity may be marked; there is severe pain, tenderness, and mobility, and in several recorded cases vomiting of a persistent character only relieved by reduction of the displacement. The congenital deformities of the sternum, notably median fissure, should be borne in mind when examining an injury of the sternum, as well as the varieties in the shape and position of the ensiform cartilage.

Dislocations of the Sternum.—Dislocation of the manubrium from the body of the bone has been occasionally recorded. Direct and indirect violence and muscular action have been given as causes. In a large proportion of the cases the associated injuries have been so severe as to destroy life. The common form of displacement has been of the body upward and forward on the manubrium. In a small number the body was displaced backward; in one a longitudinal separation was present from a fall from a height, in which the patient struck upon his back on top of a wall in such a manner as to produce hyperextension of the spine (Aurran and David). Forward dislocations of the body have been produced by blows and falls upon the upper part of the chest; falls from a height such that the spine has been violently flexed. The diagnosis depends upon the recognition of the deformity and displacement. Inasmuch as the cartilages of the second ribs usually remain attached to the manubrium, in the anterior dislocations the crescentic hollows at either upper corner of the body for the articulation with these ribs can usually be recognized on palpation, thus differentiating the condition from fracture. Generally speaking, the diagnosis offers no difficulties. The associated injuries are usually more important. In those cases which have survived, inability to maintain reduction has not caused any serious symptoms (Stimson).

Fractures of the Ribs and of their Cartilages.—Fractures of the ribs and their cartilages are very common injuries. In the statistics of various authors they are placed second, third, or fourth in point of frequency among fractures. They are exceedingly rare in childhood; during adult life they increase in frequency among men during the active working period and diminish during old age. Fractures of ribs from slight degrees of violence are common among insane patients and paralytics. The ribs may be broken by external violence or by muscular action, the latter very rarely. Still, numerous cases have been observed from coughing, sneezing, straining. The accident is said to be more common on the left side and of the lower ribs, especially the eleventh (Stimson). External violence is the ordinary cause, from blows, falls, or violent compression of the chest. Any number of ribs may be broken on one or both sides. Compound fractures occur, not from the ribs penetrating the skin but from the wound caused by the object producing the fracture. The ribs most commonly broken are the sixth, seventh, and eighth, the twelfth rib very rarely. I recently saw a case, verified by operation, in which a blow in the loin caused a fracture of the twelfth rib and a punctured wound of the kidney, with hematuria of some gravity, for which I exposed the kidney. The wound of the kidney corresponded in size to the rib, and was about an inch deep. The upper three ribs are fractured less commonly than those below. The fracture of a rib may be complete or incomplete, transverse or oblique. Angular deformity may occur, notably when several ribs are broken; the angle may be directed outwardly or inwardly. Overriding does not occur except when several successive ribs are broken. Not infrequently a rib is broken in two places. Examples of four points of fracture in one rib have been observed.

Although any portion of a rib may be fractured, the most common situation is in front near the junction of the rib with its cartilage, less commonly in the axillary region, rarely near its junction with the spine. A rib may be broken by direct violence at the point of impact, or a force which compresses the thorax and which tends to crowd the ends of a rib nearer together may cause a fracture at the point of greatest convexity of the curve. In practice it is not always easy to distinguish between these two forms. Associated injuries are common—most often of the pleura and lung, less often of the heart, great vessels, and the abdominal viscera. The lung may be wounded by the broken fragments of rib, or burst by compression at another point, even without laceration of the parietal pleura. Lacerations of the lung may give rise to hemothorax or pneumothorax, with their signs and symptoms. Emphysema of the chest wall—usually limited in extent, sometimes generalized over the entire body—is one of the commonest and most certain signs of fracture of ribs and laceration of the lung, although emphysema is more likely to occur where the lung is adherent to the chest wall at the point of fracture. It may and often does occur when this is not the case.

The Diagnosis of Fractures of the Ribs.—The diagnosis of fractures of the ribs is not usually difficult, but no doubt many fractured ribs are unrecognized and treated as contusions. There is pain at the seat of fracture, increased by deep breathing; there is often a painful and frequent cough. If the lung is injured there may be bloody expectoration, often present in slight and absent in severe injuries. The patients try to hold the injured side of the thorax as rigidly as possible, and to avoid coughing. During coughing the patient may distinctly feel crepitation at the point of fracture. Associated injuries will produce more or less grave symptoms of their own. (See Subcutaneous Injuries of the Thorax.) Palpation of the ribs will discover a point of extreme tenderness at the site of fracture. Pressure upon the rib at a distant point will often cause pain at the same place. Pressure upon the sternum will often produce pain at the point of fracture in the rib. In many cases emphysema will be present. In cases of doubt, each rib, where accessible, should be carefully palpated. Mobility at the point of fracture and deformity may be present; usually they are absent or hard to recognize unless several adjacent ribs are broken, or, in the case of a single rib, unless it is comminuted or broken in more than one place. Crepitation may sometimes be felt by placing the palm of the hand over the seat of fracture while the patient breathes, or by pressure with the fingers on either side of the point of fracture alternately. Auscultation may reveal pleuritic friction sounds under the fracture, and crepitation may sometimes be heard at the same time.

When the fracture is incomplete a positive diagnosis can hardly be made, local pain and tenderness being also present in contusions. Pneumo- and hemothorax give their proper signs. It is exceedingly rare that an uncomplicated fracture of ribs leads to empyema. Pneumonia may occur in the aged, the feeble, and the alcoholic. A rare complication of fractured ribs is

hernia of the lung. It only occurs when several adjacent ribs are broken, and one or more of them is displaced upward or downward so that a gap occurs through which the lung protrudes. It is rarely that the X-rays are needed to confirm a diagnosis of fractured ribs. In the extensive fractures of many ribs near the spine, occasionally observed, the gravity of the injury depends upon lesions more important than the fractures of the ribs themselves; but in these cases the X-rays might afford information in regard to the ribs not otherwise obtainable. The presence of fractures, with displacement old or new, could readily be shown. The suspected part of the thorax should be placed as close as possible to the photographic plate.

Fracture of the Costal Cartilages.—Fracture of the costal cartilages is not a very common injury; it may be produced by the same causes as fractures of ribs. The fracture occurs more often in elderly men whose costal cartilages have undergone partial ossification. I have recently seen a case in a young man due to a fall against the corner of a bureau. The cartilage of the seventh rib was broken close to its junction with the rib; there was easily recognized deformity. The end of the rib projected anteriorly; the cartilage was slightly depressed, this being the usual condition. The sixth, seventh, and eighth ribs are broken in this way oftener than others. If overriding is not present, mobility and soft crepitation may be felt. Under certain conditions many cartilages may be fractured, with serious or fatal injuries of the thoracic viscera, as in cases of compression of the thorax already described.

Dislocations of the Ribs.—Dislocations of ribs at the costovertebral articulations have been observed in a few cases, for the most part at autopsies, death having occurred from associated injuries. In a number of instances fractures of the vertebræ and of other ribs existed. These dislocations are very unlikely to occur as isolated injuries, but one case of this kind having been recorded (Stimson). It is improbable that a diagnosis could be made by any other means save the X-rays, or during an operation for fractured spine. There is no reason to suppose that subjective symptoms are produced which would materially differ from those of fractured ribs.

Dislocations of Ribs from their Cartilages.—Dislocations of ribs from their cartilages are infrequent. They may be produced by direct and indirect violence, and by muscular action. The signs and symptoms closely resemble those of fracture of the costal cartilages. In anterior dislocation the projecting extremity of the rib is unmistakable. In some cases the deformity, easily reduced, has returned at once. There may or may not be local pain; tenderness is present. The condition may sometimes be distinguished from fracture of the cartilage by its situation and the shape and contour of the end of the rib. Dislocation of the costal cartilages from the sternum has been observed in a few cases, sometimes associated with fractures of ribs, dislocation of the clavicle at its inner end, and fracture of the sternum. After the history of a suitable injury the signs and symptoms are localized

pain and tenderness following the accident, together with deformity felt on palpation. The usual displacement has been backward.

Separation of the Cartilages of the Ribs from One Another.—Separation of the cartilages of the sixth, seventh, and eighth ribs from one another has been observed and recorded in a few cases only, caused by a fall or violent bending of the body backward. The cartilages have been found separated—in one case (Hochenegg) widely—and movable upon one another.

DISEASES OF THE THORACIC WALL

The skin of the upper part of the back is one of the commonest sites of the various forms of acne; the eruption is chronic here as elsewhere, and appears to depend partly upon constitutional causes and partly upon want of due care of the skin. The acne papules and pustules are scarcely to be confounded with other skin diseases. They lack the peculiar pigmentation and coloring of syphilides, and do not form the circular and crescentic groupings of syphilitic papules and pustules. The back of the neck and shoulders are also favorite sites for furuncles and carbuncles. (See General Surgery.)

Acute Phlegmonous Inflammation of the Soft Parts of the Thorax.—A dangerous and often fatal necrotic and purulent inflammation of the connective-tissue planes of the chest, involving especially the intermuscular planes, sometimes the muscles and the subcutaneous fat, may originate in a variety of ways. It may follow infection through the nipple or abscess of the breast; infected wounds or operations on the soft parts of the thorax; periglandular infection from suppurating axillary lymph glands; suppurative processes originating in the jaw or in the neck, notably in the supraclavicular fossa, which burrow down into the axilla. Beneath the scapula and beneath the pectoralis major muscle are not uncommon sites. The symptoms are those of acute sepsis; a chill may occur, with high fever, prostration, a high leucocyte count, etc. Locally, there is general pain and tenderness over the affected side. The loose intermuscular planes favor the spread of infection over a large area rather than localization and perforation of the skin. After the process is well under way a diffuse boggy swelling may be present, or a boardlike induration. The disease has been mistaken for pleurisy; the constitutional symptoms are far more stormy and the signs of pleurisy are absent. The use of an aspirating needle and the withdrawal of pus, together with the general symptoms of profound sepsis, will establish the diagnosis.

Abscesses of the Thoracic Wall.—Acute abscesses arise from infection through a wound or abrasion of the skin; from the presence of a foreign body; infection of a hematoma; further, from osteomyelitis of a rib or the sternum. The signs of acute abscess are present; an aspirating needle withdraws pus. The causation is to be determined partly from the history, partly from the findings when the abscess is incised. An empyema which has perforated the chest wall—so-called "empyema necessitatis"—is to be differentiated from an

ordinary abscess by percussion and auscultation of the chest, by the introduction of an aspirating needle into the pleural sac, and the presence of dyspnea, cough, and immobility of the chest.

Peripleuritic Abscess.—Primary acute abscess originating outside the costal pleura and beneath the ribs is a rare condition. The abscess may be of considerable size, and tends to perforate the chest wall rather than the pleura, and appears as a tender, fluctuating swelling, giving the local signs of deep-seated acute or subacute abscess. The differential diagnosis from a perforating empyema may be impossible. The following consideration may be of value: A peripleuritic abscess may appear anywhere and be surrounded by normal resonance and breathing; an empyema is usually at the bottom of the pleural sac; abscess of the lung may perforate the chest wall and form a tumor giving the signs of abscess beneath the skin. There will usually have been a history of pneumonia, an injury, aspiration of a foreign body, etc. Failing some such history, the condition may remain unrecognized until incised and explored. Tuberculous cavities in the lungs may occasionally perforate the thoracic wall and give rise to an abscess containing pus and air. Such an abscess will give a tympanitic percussion note and will not usually be reducible; aspiration will withdraw pus and air. A hernia of the lung, unless strangulated or inflamed, will be reducible, and vesicular breathing may be heard over it as well as tympanitic resonance. There are a number of instances on record where an aneurism of the aorta has perforated the chest wall and been incised as an abscess. The skin over such an aneurism may be acutely inflamed, fluctuation is present; if the sac is much thickened, or partly obliterated by layers of fibrin, pulsation and bruit may be wanting. In any doubtful case a fine needle should be introduced, and the character of the contained fluid determined. It is to be remembered that if the sac contains clots, a dry tap may result. Further, an abscess may overlie an aneurism. Under such conditions a careful physical examination, the history of the case, and ordinary care will prevent disastrous error. An X-ray examination is a useful aid in the diagnosis.

Actinomycosis.—Actinomycosis of the lung may perforate and produce an actinomycotic abscess of the chest wall. The disease is characterized by a very chronic course, by the formation of abscesses and sinuses with indurated walls, and by the presence of the characteristic granules in the discharge. (See Actinomycosis.)

Cold Abscess of the Thoracic Wall.—Tuberculous abscess gives the history of a chronic process without signs of acute inflammation; the fluctuating swelling is covered by white skin, is painless and insensitive. The size of such an abscess may be small or very large, in some cases as large as a child's head. In most cases a cold abscess will have originated in a bone, a rib, the sternum, a vertebra, the scapula, and often, at some distance away, the pus having traveled perhaps a foot or more, beneath the muscles, before it has reached the surface. Primary tuberculosis of muscles being rare, the

possibility of an intrathoracic origin should not be forgotten, and careful search with a fine probe may reveal it during the operation.

Acute Osteomyelitis of the Ribs, Sternum, or Clavicle.—Acute osteomyelitis of the ribs, sternum, or clavicle rarely occurs as an isolated lesion; usually other bones, and notably the long bones of the extremities, are simultaneously involved. A few such cases have, however, been recorded, especially after typhoid fever and other infectious diseases. Local pain, tenderness, and swelling, and the formation of an abscess, together with the suppurative lesion in the bone and periosteum, are present. In the case of the ribs the anterior extremities appear to be most commonly affected. I saw a focus in the manubrium and the sixth rib associated with acute osteomyelitis of the tibia; a similar lesion was observed in another case after a cellulitis of the forearm.

Tuberculous Periostitis and Osteomyelitis of Ribs and Sternum.—Tuberculous periostitis and osteomyelitis of ribs and sternum is more common than the acute suppurative form; the ribs are more often affected than the sternum. The disease occurs at all ages; in children and old people less often than in young and middle-aged adults. The lesion may be primary in the periosteum and bone, or secondary to tuberculosis of the soft parts or to intrathoracic lesions. Other tuberculous lesions, notably phthisis, are often present. Primary tuberculosis in the bone is the rule, in the periosteum the exception. The lesions are tuberculous infiltration of an area of bone, usually limited in extent, softening, the formation of an abscess, sometimes of a small sequestrum. The tendency to burrow beneath or through the pleura is small, the abscess finds its way outwardly. Primary tuberculous periostitis, by depriving the rib of its blood supply, may lead to the formation of a considerable sequestrum. Several foci may exist in one bone or many ribs may be involved. The perichondrium of the costal cartilages may also be the seat of tuberculosis. The cartilage undergoes necrosis, and remains as a sequestrum at the bottom of a chronic tuberculous sinus. In the sternum multiple foci often form, so that a considerable portion, or even the entire sternum, may be involved. The abscesses usually break through the skin, leaving tuberculous sinuses and ulcers behind. Rarely, such abscesses form on the posterior surface and break into the mediastinum, to end fatally. The diagnosis of tuberculosis of ribs and sternum is not often difficult; there is a history of a chronic, painless, circumscribed enlargement of one or more ribs, or of a similar tumor over the sternum; the formation of a cold abscess, which finally perforates the skin and discharges abundant tuberculous pus. The probe often strikes immediately against bare, roughened, or softened carious bone. Should the fistulous tract be long or tortuous, and difficult to follow with a probe, the following expedient may be used to find the original focus: The sinus is injected with iodoform or bismuth emulsion; an X-ray picture is taken; the iodoform or bismuth casts a dense shadow, and often indicates plainly the point of origin of the process.

Syphilitic Periostitis and Osteomyelitis of Ribs and Sternum.—Syphilitic periostitis and osteomyelitis of ribs and sternum occurs in the later stages of the disease as a circumscribed, or more diffuse, gummatous infiltration of the periosteum or bone, or both. There is formed a slowly growing circumscribed enlargement of the rib, often spindle-shaped, tending to spread along the length of the rib, and generally nearly painless. Upon the sternum a more or less prominent tumor is formed, hard or elastic at first; later, softening may take place, with the formation of a characteristic crateriform gummatous ulcer leading to exposed or necrotic bone, or to one or more sinuses, not always easy to distinguish from tuberculosis. Points which may aid in diagnosis are: Syphilitic gummy material of a dirty-white homogeneous appearance may be visible; syphilitic pus is often thick, and does not contain flocculi of cheesy material, as does tuberculous pus. Other signs, or a history of syphilis may be obtained. Syphilis responds to iodid and mercury. It is to be borne in mind that syphilis and tubercle may coexist in the same lesion. Before breaking down, gummata are often mistaken for sarcomata; the diagnosis is not always possible without vigorous antisyphilitic treatment.

Intercostal Neuralgias.—Under this title I intend to mention painful affections of the intercostal nerves from various causes, whether true neuralgias or not, among them the expression of an anemic, hysterical, or neurasthenic state. Neuritis, sometimes associated with herpes zoster of the chest wall. Exposure to cold and wet; autointoxication from the intestinal tract, gout, uric-acid, and rheumatism are regarded as adequate causes by some observers. Deformities and diseases of the spine; fractures of ribs, with deformity or pressure upon the nerves by callus formation. Pressure by inflammatory infiltrations or new growths. All these conditions, and even others, must be taken into account in arriving at a diagnosis. The pain will vary in character in different cases. In true neuralgias without evident organic lesion it is apt to be paroxysmal and severe, with intermissions. The pain following exposure to cold and wet is felt chiefly during active movements of the intercostal muscles. Pain due to the pressure of tumors, callus formation, and aneurism is apt to be continuous with exacerbations. The conditions are here mentioned because the true neuralgias, if persistent, are sometimes treated surgically by stretching or avulsion of the nerves.

Tumors of the Thoracic Wall.—All the varieties of benign and malignant tumors may occur in the soft tissues and bony framework of the thorax. Lipoma is the most frequent; for its general characters, see Tumors. On the thorax they form sessile or pedunculated growths which may reach an enormous size, and interfere, by their weight, with locomotion. A submammary lipoma may have the appearance of an hypertrophied breast; the gland may undergo atrophy from pressure. A few cases of lipoma have been observed in which the tumor lay partly within, partly without, the thoracic cavity (*subpleural lipoma*). The two portions of the growth have communicated by a narrow isthmus. Fibromata in the form of fibroma molluscum and keloid are

very common. (See Tumors.) Other fibromata occur deeply seated beneath the muscles. They are to be distinguished from lipoma by their dense, hard consistence, and by the fact that the deep lipomata are very movable tumors, while the fibromata are notably less so. These deep fibromata may also have a partially subpleural situation. Hemangiomata of various types also occur, and present their ordinary characters. I saw, some years ago, an enormous congenital cavernous angioma of the thorax. The patient was a man of thirty years. The tumor occupied the entire axilla, and extended well forward to the mammary line, and downward in the mid-axilla, nearly to the costal border; it formed a blue, spongy mass, easily compressible, containing large venous channels and spaces. No operation was possible, and its possessor very properly guarded it from injury with jealous care. The cavernous angiomata sometimes remain stationary for years and suddenly take on a rapid growth. Hence the wisdom of early removal. Hairy and pigmented nevi are quite common upon the chest and back, and if they become large may, in women, become worthy of operative removal. They are sometimes the starting point of melano-sarcoma. *Neuroma* and *neurofibroma* of the cutaneous and intercostal nerves of the thorax are not rare; they present as nodules, sometimes tender and painful, in the course of the nerves. (See Neuroma.) Plexiform neuroma of the intercostal nerves has been observed. I removed a plexiform neuroma from the dorsal region just to one side of the spine. The patient was a young girl. The tumor formed a soft, slightly elevated mass beneath the skin, circular in shape, and as large as a tea saucer. There had been no pain in the growth. The bundles and fusiform masses of soft gelatinous tissue extended deeply into the muscles of the back, and required quite a bloody dissection for their removal. The reported cases are not numerous.

Fig. 237.—Lipoma of the Thoracic Wall. (New York Hospital, service of Dr. Bolton.)

Lymphangiomata have their origin in or near the axilla in the majority of cases; they form soft tumors, usually mistaken for lipomata. An aspirating

needle introduced in the tumor withdraws clear, colorless, or straw-colored fluid. Like the cavernous hemangiomata, they sometimes begin to grow rapidly, and may penetrate deeply beneath the muscles and into the cavity of the thorax. Atheromatous and dermoid cysts may occur, notably in the back. (See Tumors.)

Enchondromata of the Ribs and Sternum.—Cartilaginous tumors grow, commonly, from the junction of a rib with its cartilage. Less often from the sternum, and, in all the recorded cases, from the body of the bone. They may follow contusions or fractures of ribs. They form slow-growing painless nodules of smooth or irregular contour attached to a rib. After they have attained a certain size, they usually undergo a central or disseminated myxomatous degeneration, so that there may be a thin cartilaginous shell inclosing a cavity filled with mucous tissue; or the tumor may consist of irregularly distributed, hard and soft areas. Combinations with sarcoma and sarcomatous degenerations of cartilaginous tumors are frequent. The enchondromata of the ribs quite commonly recur after operation and form metastases; they are, thus, dangerous tumors. Since they grow slowly, and are not painful, they are first seen by surgeons after they have reached a considerable size. They may have included several ribs and grown inward, involving the pleura and mediastinum. If let alone, pressure symptoms of progressively dangerous character occur, and finally destroy life. Their early operative removal is, therefore, highly important.

Sarcoma of the Thoracic Wall.—Primary sarcoma of the thorax takes origin commonly in the ribs and sternum, either from periosteum or bone substance. They are generally very malignant and dangerous tumors, of rapid growth and of various degrees of hardness, according to the character of tissue composing them. Localized or generalized softening is common from degenerative changes. They usually invade the pleura quite early, and involve a wider area of tissue than external appearances would indicate. Externally they sometimes break down, form fungating tumor masses, which may bleed the patient to death (see Fig. 77). Secondary tumors are formed in the vicinity of the primary growth and metastases in distant organs. As stated, they often occur in combination with chondroma. Central sarcoma of a rib is, at least in the beginning, rather less malignant than the periosteal type. The periosteum may remain intact for some time. A fusiform swelling of the rib occurs of fairly rapid growth. Early operation may save life. Certain highly vascular sarcomata, originating in the sternum, may form soft pulsating tumors, somewhat resembling an aneurism of the aorta after it has perforated the sternum; the pulsation may also be a transmitted one, if the tumor has destroyed the sternum and invaded the mediastinum. Primary sarcomata of the skin and soft parts of the thorax are rather rare tumors. They usually occur as multiple nodular tumors in the skin, which grow rapidly, ulcerate, and destroy life in one or other manner common to malignant tumors. I removed a large rapidly growing sarcoma from the axilla of a woman some

years ago. The healthy tissues were widely excised. The woman had remained well for several years when I lost sight of her.

Carcinoma of the Thoracic Wall.—Primary carcinoma of the skin occurs chiefly as slow-growing superficial epithelioma, with ulceration, but no notable tendency to invade the deeper tissues or to form metastases. (See Tumors.) Secondary carcinoma occurs, for the most part, secondary to carcinoma of the breast. (1) As multiple nodular tumors scattered over the skin of the chest, sometimes of the abdomen and back; the nodules are, at first, quite small—as large as a pea—of stony hardness, in the thickness of the skin (carcinoma lenticulare). They continue to grow and coalesce. I have seen them come out in successive crops at intervals of a few months. (2) As a diffuse boardlike infiltration of the skin and underlying soft parts, firmly adherent to the ribs, constituting the condition known as "cancer en cuirasse." The prognosis of these cases is absolutely bad under any form of treatment, including the X-rays.

Fig. 238.—Cancer en Cuirasse Following Carcinoma of the Breast. Note the enormous edema of the right arm from pressure upon the axillary vein. (Kindness of Dr. B. S. Barringer.)

Echinococcus has been observed a few times in the thoracic wall, usually in the muscles. The tumor gives the physical signs of a cyst, or has been mistaken for lipoma. The diagnosis rests upon the aspiration of clear fluid and the finding of hooklets. If inflamed, the diagnosis of abscess would be made. (See Echinococcus.)

DISEASES OF THE PLEURA

General Considerations.—From the surgical standpoint, the injuries and diseases of the pleura attended by an accumulation of fluid in the pleural sac are of diagnostic interest. Such accumulations are of a very varied character, and give rise to symptoms of two kinds: those due to pressure upon the intrathoracic organs, and those due to the special causative factor of the process and to the character of the fluid itself. The pressure symptoms occur only when the fluid is large in amount, so that the lung upon the affected side is compressed and ceases to functionate more or less completely. The heart is displaced; the function of the other lung is more or less interfered with; the

blood-vessels and other structures in the mediastinum may be seriously compressed. The symptoms are dyspnea, cyanosis, and a rapid pulse-rate. On inspection and measurement, the affected side of the chest is distended and immobile. The intercostal grooves are obliterated; in children they may even bulge. In measuring the chest with the cyrtometer, it is to be remembered that, normally, the right side of the chest measures about half an inch more than the left in right-handed people. The measurements may be made at the level of the nipple or the angle of the scapula with the arms abducted to a right angle with the body. A convenient tape consists of a fairly thick strip of lead applied to the skin. This retains its shape, so that a tracing of the shape of the two sides of the chest may be made on a sheet of paper, measured and compared. In large pleuritic effusions the difference may amount to an inch or an inch and a half.

Palpation.—There is absence or diminution of vocal fremitus, sometimes preserved in children, and rarely transmitted through adhesions of lung to the chest wall. Percussion gives a flat note over the fluid; by this means an increase in the quantity of fluid may be measured from time to time. If the effusion is large, there is tympanitic resonance of a peculiarly resistant board-like quality above the level of the fluid over the compressed lung. This is to be noted especially in the infraclavicular and supraclavicular regions, and in the supraspinous fossa. The level of the fluid is higher behind than in front when the patient is in the erect position. Sometimes the level of the fluid and the signs may be made to change by shifting the position of the patient.

Auscultation.—Before an effusion is marked, there is sometimes a creaking friction sound or fine crepitation where the inflamed pleural surfaces are rubbing one on the other. When the fluid has accumulated in quantity there is absence of breathing, or diminished breathing. The breathing, though distant, may be high-pitched and bronchial. Over the compressed lung there is roughened breathing, often high-pitched; râles of various kinds may be present. Over the fluid there is absence of voice or distant voice. Bronchial voice sometimes over the fluid, but especially at the level of the fluid there is egophony —i. e., the voice has a nasal, bleating quality. If the pleural cavity is obliterated by adhesions no effusion can occur. If localized adhesions exist, fluid may accumulate over limited areas; the physical signs will then vary, according to local conditions. The apex beat of the heart is displaced to one or the other side. "In right-sided effusions the apex beat may be lifted to the fourth interspace or be pushed beyond the left nipple, or may even be seen in the axilla. When the exudation is on the left side the heart's impulse may not be visible; but if the effusion is large, it is seen in the third and fourth spaces on the right side, and sometimes as far out as the nipple, or even beyond it" (Osler). (For further details the reader is referred to works on internal medicine.) In discussing the causation of special kinds of pleuritic effusions and their diagnosis, it is convenient to divide them into several groups: I.

Inflammatory effusions—serous, sero-fibrinous, and purulent. II. Transudations due to circulatory disturbances. III. Hemothorax. IV. Chylothorax.

Inflammatory Effusions.—With the exception of infection accompanying open wounds of the pleural sac, inflammations of the pleura are usually secondary to general infections or to local processes of varied character. Any of the inflammations of the lung; pneumonias of all kinds; abscess and gangrene of the lung may be, and often are, accompanied by pleuritis; abscess or cellulitis of the mediastinum; malignant tumors of the mediastinum and lung; infected bronchial glands; ulcerated carcinoma of the gullet; inflammatory processes of the peritoneum, or of any of the abdominal viscera, with or without an abscess which perforates the diaphragm. The character of the fluid exudate may be serous, sero-sanguinolent, sero-purulent, purulent, or putrid. The recognition in the exudate of bacteria is often very important in the diagnosis, treatment, and prognosis of the case. While very many bacterial forms have been found, the pneumococcus, the pyogenic staphylococci and streptococci, the tubercle bacillus, and various saprophytic forms, are those which give a more or less distinctive character to the disease. It often happens that several forms are associated. *A purely serous pleuritis*—the fluid being clear, or nearly so, containing few cellular elements, and sterile—seldom requires surgical treatment. Many of the cases are doubtless tubercular. It is believed that the poison of acute articular rheumatism, or even exposure to cold and wet, may act as an exciting cause. The fever and constitutional disturbance are moderate. At the beginning of the disease there is usually sharp pain, referred to the nipple or axilla, increased on deep inspiration. As the effusion increases the pain diminishes or disappears. Cough may be present or absent. The difficulty in respiration varies with the quantity of the exudate. The disease often gets well by absorption of the fluid. In some cases a serous exudate may be present, examination of which may show the presence of the pneumococcus, or of pus-producing organisms. *In these cases the effusion may later become purulent.* Sometimes aspiration near the bottom of the pleural sac may withdraw sero-pus, aspiration at higher level having shown the presence of clear fluid.

Empyema.—A purulent inflammation of the pleura may originate in many ways, some of which have been indicated. When the condition follows a pneumonia, a wound of the thorax, perforation of a tuberculous cavity into the pleura, a purulent mediastinitis, or perforation of a carcinoma of the esophagus, a subphrenic abscess, or a purulent peritonitis, or occurs in the course of a severe general sepsis or pyemia, the cause is not far to seek. In other instances, the existence of a purulent focus which cannot be located, or infection through organisms existent in the blood, may be offered in explanation. The character of the organisms present should be identified, if possible, by stained smears of the pus and by cultures. For the purpose of obtaining pus for examination, a sterile hypodermic syringe and a long needle may be introduced in the fifth or sixth space in the axillary line. The signs and symptoms of

empyema are those already described as present when the pleura contains free fluid, to which are added the symptoms of a more or less pronounced sepsis. There is fever and prostration, sometimes a chill, loss of appetite, rapid emaciation, etc. (See Septic Diseases.) In a certain number of cases of pleuritic effusion of the purulent variety, rarely in the sero-fibrinous form, and nearly always upon the left side, the thoracic wall over the area occupied by the effusion pulsates synchronously with the heart. This sign may also be present as an external pulsation in empyema necessitatis. When empyema follows pneumonia, the signs and symptoms usually do not develop until some days after the fever of the pneumonia has subsided. The pneumococcus is found in the pus, sometimes associated with pyogenic forms.

In many cases, empyema develops from a preëxistent sero-fibrinous exudate; in these, the alteration from a serous to a purulent exudate may be gradual and not marked by any sudden change in the character of the physical signs or general symptoms. There may be little or no cough or pain. The patients, especially children, have wider daily ranges of temperature, they become weaker, markedly anemic, and often have profuse sweats. In children, loud bronchial breathing over the fluid is not uncommon. The empyema caused by the pus-producing organisms alone occurs from wounds of the pleura, and in the course of severe infectious diseases; pleuritis complicating scarlet fever and typhoid fever is usually purulent, or as a complication of general or local septic processes of any sort. Sometimes by direct extension through the diaphragm from the belly, or from a neighboring purulent focus in the lung, the mediastinum, etc. Sometimes as a metastatic infection through the blood or lymph current. The course of the disease is apt to be more severe and dangerous to life than is the case with pneumococcus infections of the pleura.

Putrid Empyema.—Putrid empyema occurs when open wounds of the pleura, notably in the presence of hemothorax, are infected with saprophytes alone, or in conjunction with pyogenic organisms. An ulcerating carcinoma of the gullet; an abscess or gangrene of the lung, which perforates the pleura; or a process having its origin in traumatic or pathological perforation of the stomach or intestine, may result in this form of empyema. The pus has a stinking putrid quality. The constitutional symptoms are those of combined sapremia and sepsis. The prognosis is grave.

Tuberculous Pleuritis.—Tuberculous pleuritis occurs as the result of infection of the pleura from tuberculous foci in the lung; as a part of a general miliary tuberculosis; as an infection from tuberculosis of the ribs, sternum, and vertebræ. The effusion may be serous, sero-sanguinolent, or purulent. Pyopneumothorax is not uncommon. The *presence of blood* is strongly suggestive of tuberculosis or of malignant disease. The recognition of tubercle bacilli in the serous and sero-sanguinolent cases is sometimes easy, sometimes difficult. If they are not found by the persistent use of the centrifuge and staining and examination of numerous smears, inoculation of guinea pigs may be successful. In mixed infections by tubercle bacilli and pyogenic organ-

isms, animal inoculations often fail, the animals frequently dying of septic infection.

Noninfectious Effusions in the Pleural Cavity.—Hydrothorax.—The diseases of the heart and kidneys associated with profound circulatory disturbances, and cachexias of various kinds, may be associated with watery effusions in the pleural cavity, usually bilateral. They are seldom treated surgically. Tapping and aspiration are sometimes of temporary benefit.

Hemothorax.—Aside from trauma, hemothorax may occur from ruptured aneurisms; or ulceration of vessel walls, caused by the pressure of foreign bodies, tuberculous, cancerous, or other ulceration. The signs and symptoms have been described under Injuries of the Thorax.

Chylothorax.—Open wounds or subcutaneous lacerations of the thoracic duct in the chest cavity, and, rarely, ulceration caused by malignant tumors, may permit the escape and accumulation of chyle in the pleural cavity. The fluid is of a creamy consistence and color, contains usually sugar; exhibits under the microscope leucocytes and finely divided fat drops. It is to be distinguished from an effusion, somewhat resembling it, present in some cases of tuberculous pleuritis, and in carcinoma of the pleura and lung. In these conditions the fluid is of a milky color, thinner than chyle, seldom contains more than a trace of sugar. Under the microscope, fat drops, degenerated epithelial and round cells, granular material, and fragments of tumor or cheesy material may be found.

Tumors of the Pleura.—Benign tumors of the pleura have been observed—fibroma, angioma, osteoma. Their presence is not likely to be suspected unless they grow to a large size, cause dullness on percusion, displacement of the heart, etc. A needle thrust into such a tumor gives a sense of resistance much greater than that of fluid or lung tissue. Of the primary malignant tumors of the pleura, endothelial cancer is the most frequent. The pleura is greatly thickened, there is dullness on percussion, and feeble or absent breathing. Aspiration may withdraw blood or chocolate-colored blood-stained fluid. Secondary malignant tumors of the pleura, sarcoma and carcinoma, occur with great frequency, as an extension by continuity of structure, or, as a metastatic process, in cancer or sarcoma of the mamma, the thyroid gland, the lung, the mediastinum, the liver, stomach, intestine, and elsewhere. The signs and symptoms are not apt to be marked until the intrathoracic growth has attained some size. The growth may consist of disseminated nodules or of massive infiltrations. Early symptoms are pleuritic pains. The presence of an accessible primary growth, or a history of its removal, together with rapidly progressive cachexia and absence of fever, will aid the diagnosis. When the tumor has reached a considerable size, dullness or flatness on percussion and dyspnea may be present. Introduction of an aspirating needle may give the sensation that the needle is passing through a solid mass of tissue, or withdraw blood-stained or milky fluid. Fragments of tumor cannot usually be extracted with the needle; but a sensation of solid tumor being appreciated by

the needle, a harpoon or punch may be used to remove a fragment of tissue, when doubt exists as to the diagnosis.

Echinococcus of the Pleura.—Echinococcus of the pleura is rare as a primary condition, more common as an invasion by continuity of structure in echinococcus of the abdomen. The signs are those of a tumor in the thorax—limited dullness or flatness. Sometimes a distinctly localized bulging has been noted. Puncture may reveal the characteristic fluid or hooklets. (See Echinococcus.)

Actinomycosis of the Pleura.—Actinomycosis of the pleura is usually secondary to actinomycosis of the lung. Recognition of the granules in the sputum is necessary for a diagnosis, unless perforation of the thoracic wall occurs. (See Actinomycosis of the Thoracic Wall and Actinomycosis.)

DISEASES OF THE LUNG

Diagnosis of the Surgical Diseases of the Lung.—In exceptional cases the following affections of the lungs are amenable to surgical treatment by operation: Abscess of the lung; gangrene of the lung; bronchiectasis; circumscribed areas of tuberculosis; echinococcus; actinomycosis; tumors of the lung. Conditions favoring such a possibility are: (1) Localization of the disease in a circumscribed portion of lung tissue adjacent to the thoracic wall and in an accessible locality. (2) Adhesions between the affected portion of lung and the thoracic wall. While in many cases no absolute knowledge that such conditions exist is obtainable before opening the pleura, yet adherent lung is probable if the disease is of long duration; if the affected portion of the chest is immobile; if the intercostal spaces are depressed; if the costal pleura is found edematous, inflamed, and thickened. If the process has already invaded the soft parts of the thoracic wall, adhesion of lung at that point may be assumed. It is believed by many surgeons that the introduction of a trocar or aspirating needle through the unopened costal pleura in supposed pyogenic diseases of the lung is dangerous, since the lung tissue is so elastic that such an instrument penetrates it with difficulty. If the adhesions are soft, the lung may be pushed bodily away and at the same time infectious material may be permitted to escape into the pleural cavity. The advantage of such introduction is that, if the lung is firmly adherent, the needle, after its introduction, will not move during respiration. Adhesion is thereby demonstrated. In any event, it is probably safer to unite the lung and costal pleura by a series of closely applied interrupted catgut or silk sutures before incising the costal pleura. The lung once fixed, the costal pleura may be incised, and the lung explored with suitable trocars or needles. Palpation of the lung through the unopened costal pleura stripped widely from the ribs is more dangerous and less satisfactory.

Abscess of the Lung.—Abscess of the lung may follow wounds of the lung—stab and gunshot; pneumonias of various kinds; empyema; aspiration of for-

eign bodies into the lungs; septic processes in the neighboring or in the abdominal viscera (liver, intestine, vermiform appendix, peritoneum) by direct extension or through the lymph channels; metastatic abscesses in pyemia, usually multiple. The pneumococcus, the pyogenic cocci, staphylococci, streptococci, colon bacilli, etc., may be the exciting organisms. Immediately following a pneumonia, or one or other of the conditions mentioned, the diagnosis of abscess of the lung depends upon the following symptoms and signs. In the presence of septic fever, more or less marked, the patient, during a fit of coughing, expectorates a considerable quantity of pure pus. The pus is usually thick and creamy, and has a sweet, sickening odor, but is not putrid. It may be yellow, green, brown, chocolate-colored, prune- or plum-juice colored. Under the microscope, in addition to pus cells—usually in a state of fatty degeneration—and fat drops, there are found abundant hematoidin crystals, and shreds of fibrous and elastic tissue originating from the walls of the pulmonary alveoli, sometimes containing pigment; these fragments may be so large that the form of the alveoli is more or less evident. Numerous bacteria, to be identified by staining and cultures, sometimes fat and cholesterin crystals. The hematoidin crystals consist of ruby-red, orange-colored, or dark-brown rhombic plates, and of needles or bundles of needles. Sometimes portions of such crystals may exist as granules in the pus cells. *The characteristic feature is the occurrence of such crystals free in the pus.*

The physical signs of abscess of the lung are those of consolidation of the lung. If, after a large quantity of pus has been expectorated, the previously dull or flat area becomes tympanitic, it indicates that an abscess has burst into a bronchus, and that its contents have been expectorated. A repetition of this series of events still further confirms the diagnosis. A frequent concomitant is empyema. In the given case it may be impossible to tell whether an abscess of the lung or an empyema with perforation of a bronchus is present. Absence of, or but few, elastic fibers in the pus would favor the latter condition. The presence of tubercle bacilli points to the formation of a tuberculous cavity rather than a true abscess. It is to be borne in mind that tuberculous cavities more commonly form near the apex of the lung, while abscesses are more frequent near the base. A putrid odor indicates gangrene; entire absence of elastic fibers indicates, with a suitable history, bronchiectasis. The X-rays, both the fluoroscope and radiographs, are capable of furnishing valuable aid in the diagnosis of abscess of the lung. A tube of slight resistance giving the greatest possible differentiation of densities should be used. If the abscess is full of pus, a dark shadow will be shown on the fluoroscope and a light area on the X-ray negative. If the abscess cavity is empty, the conditions will be reversed.

Gangrene of the Lung.—Putrid necrosis of lung tissue may take place in a previously healthy organ or in one already the seat of disease. The condition may be circumscribed or diffuse. Predisposing causes are diabetes, chronic alcoholism, debility from old age, infectious diseases, or cachexias of various

kinds. The disease is more common in men than in women, and occurs in the right lung more often than the left. In the diffuse form an entire lobe, or more, may be involved. Various forms of saprophytic bacteria associated with pyogenic staphylococci are regularly present, together with a form resembling leptothrix buccalis, to which the name leptothrix pulmonis has been given. The determining conditions are, in a large proportion of cases, ordinary croupous pneumonia; and the aspiration of foreign bodies into the bronchi. Such bodies may be *corpora aliena* of any description accidentally aspirated, or portions of broken-down tumor tissue from carcinomata, situated in the upper air passages. Further, necrotic tissue or pus from abscesses or suppurative processes of mucous membrane (middle-ear disease through the Eustachian tube into the pharynx, diphtheria, etc.). Putrid decomposition of the contents of a tuberculous cavity or bronchiectasis may invade the walls of the cavity in the lung with the production of gangrene. Suppurative or gangrenous processes of the gullet (carcinoma), bronchial glands, mediastinum, abdominal organs, which invade the lung. Metastatic infection from distant organs, gangrenous ulcers of soft parts or of bone, giving rise to septic emboli and thrombi which lodge in the lung, producing an infected infarct. Rarely, simple embolism of the pulmonary artery. Infected wounds of the lung—contused and lacerated, as from broken ribs, stab and gunshot wounds.

Constitutional Symptoms of Gangrene of the Lung.—The constitutional symptoms of gangrene of the lung are those of mixed sapremic and pyogenic intoxication, often of a rapidly fatal character, sometimes more chronic. The fever shows marked exacerbations; there are often chills, sweating, and diarrhea; absolute loss of appetite, etc. The local signs in the lung are, at first, those of consolidation, more or less marked, impossible to detect if the gangrenous areas are small and disseminated. When the dead tissue has softened, coarse moist râles and amphoric breathing are present over the affected area. By far the most characteristic diagnostic sign of gangrene of the lung is the sputum. The patient *coughs* up daily a large amount (200 to 600 c.c.) of putrid, stinking material; the odor is that of carrion, and has been likened to the burned horns or hoofs of animals. The breath is also horribly offensive in most cases. The color of the sputum is gray, green, dirty greenish-brown, or may contain streaks of recent blood. Upon standing, the sputum soon separates into three layers: The uppermost layer is foamy, muco-purulent, dirty-green or brown in color, and contains little masses of coherent muco-pus. The middle is watery, partly clear or cloudy; little shreds and tags hang down into it from the upper layer. The third layer consists of pus, containing much black or green broken-down lung tissue, in shreds and small masses, often recognizable as containing elastic fibers under the microscope. Small, partly decomposed blood clots; further, larger or smaller semisolid "Dittrich's plugs," as large as a pea or bean, of a yellow or green color, consisting of granular detritus, bacteria of various kinds, fat crystals, and pigment granules. The differential diagnosis from the sputum of putrid bronchitis

is to be made by the absence of fragments of lung tissue in this latter condition.

Traube distinguished three conditions necessary for a diagnosis of gangrene of the lung: (1) The physical signs observed from day to day, indicating the rapid formation of a cavity in the lung; (2) the characteristic sputum containing elastic fibers; (3) the presence of Dittrich's plugs. The complications of gangrene of the lung are pyemia; perforation of the gangrenous cavity into the pleura (with putrid pyopneumothorax), mediastinum, abdomen; adhesion to and perforation of the chest wall, with the formation of an emphysematous gangrenous process of the thoracic wall, abscess of the brain, and hemoptysis. If the gangrenous area is small, and does not empty itself into a bronchus, so that the characteristic expectoration and odor are absent, the diagnosis cannot be made. The prognosis of the disease is so unfavorable that operative treatment is justifiable when any hope exists of reaching, opening, and draining the focus. In order to succeed, the operation should be done as soon after the diagnosis is made as possible.

Bronchiectasis.—*Sacculated* dilatations of the bronchi only can be treated surgically, other forms cannot. (For the pathology, see works on general medicine.)

Symptoms.—There is a history of chronic bronchitis; sooner or later characteristic symptoms appear. The patients are subject to periodic attacks of violent coughing, which may occur one or several times during the day, often in the morning. The coughing results in the expectoration of a large quantity of pus or muco-pus, amounting in some cases to a pint or more. The sputum may or may not have a stinking or a putrid odor; on standing it separates into an upper clear watery layer, and a lower layer of pus, bacteria, and detritus, fat, etc. Blood may be present in greater or less quantity. Hemorrhages are not very rare. Fever is due only to complications. The general health suffers, the patients have chronic cyanosis, the fingers become clubbed, the nails curved. Associated interstitial pneumonia and contraction of the lung causes depressions in the chest and deformity of the spine. Emphysema of the other lung is common. Infection of the lung surrounding the cavity may lead to abscess and gangrene. Amyloid degeneration of the liver and kidneys may occur. The physical signs are sometimes clearly defined, sometimes not. In typical cases dullness alternates with tympanitic or cracked-pot resonance, according as the cavity is filled or empty. Auscultation may give amphoric or bronchial breathing. Râles will be present or absent, according to the contents of the cavity. If the presence of a single suitably placed cavity can be assumed, its operative drainage, or resection of a portion of lung has, in some cases, relieved the symptoms and improved the general condition.

Tuberculosis of the Lungs.—The surgery of tuberculosis of the lung has hitherto been confined to resection of circumscribed portions of lung tissue in cases where the disease was confined to the apex and to the drainage of tuberculous cavities. (For the diagnosis of tuberculosis of the lungs the reader is

referred to works on general medicine.) The fact that in a few cases resection of a tuberculous focus of lung has resulted in cure, is encouraging, but it must always be difficult to know when such a focus is solitary. The drainage of tuberculous lung cavities as a palliative measure may be justifiable if the retention of its contents is a serious element in the case.

Echinococcus of the Lung.—Echinococcus is rare in America. In those countries where the disease is common, the lung is, next to the liver, its most frequent site. Out of one hundred and seventy-six cases collected by Madelung, it occurred nineteen times in the lung. The signs and symptoms are readily mistaken for those of phthisis; sometimes for tumor of the lung, with effusion into the pleura, or for ordinary pleuritic effusion. There is cough with mucopurulent sputum, from time to time tinged with blood, pain in the chest, loss of flesh and strength, dyspnea from pressure. If the cyst is large there may be bulging of the chest wall. Percussion gives flatness over the cyst, and auscultation, absence of breathing or feeble bronchial breathing; the line of flatness may be irregular. If the tumor bursts into a bronchus, the patient may choke to death, or expectorate clear watery fluid and hooklets, from which the diagnosis can be made. Cure has followed from shriveling of the cyst; in other cases abscess or gangrene of the lung. If the thoracic wall is perforated, cysts may be discharged through an opening in the skin. Rupture into the pleura may give rise to pyopneumothorax if the rupture communicates with a bronchus. In general, the picture closely resembles that of phthisis without the presence of bacilli. Puncture of the cyst with an aspirating needle withdraws clear watery fluid containing but little albumen and a notable quantity of sodium chlorid; in some cases hooklets are discoverable. The diagnosis has rarely been made until characteristic elements have either been discharged externally through the skin or coughed up. X-ray examination would very probably show a definite shadow, but its nature would be unknown.

Actinomycosis of the Lung.—(For the diagnosis, see Actinomycosis.) Hitherto surgical treatment has availed but little.

Tumors of the Lung.—Carcinoma of the Lung.—Primary cancer is rather rare. Secondary cancer is very common. Primary growths are confined to one lung, and are solitary. Secondary tumors usually involve both lungs, and are multiple and disseminated. Primarily, both cylinder-celled and squamous carcinoma occur; the former is more common. The diagnosis of the secondary forms is usually plain. The occurrence of pulmonary disease following the removal of a cancer of the breast, the rectum, the stomach, etc., is always suggestive. The diagnosis of primary cancer, on the other hand, is difficult or impossible at a time when operative removal can be of real value. The disease occurs in advanced life. If the tumor has a central location, and is covered by a layer of healthy lung tissue, no symptom may occur until it has reached a large size. If the tumor is superficial, the signs are those of a circumscribed area of consolidated lung. There is bronchitis, sometimes with "prune-juice" expectoration; pain in the side, loss of flesh and strength.

There may be pleuritic effusion, and in a moderate number of cases such effusion may contain blood or numerous cells, or groups of cells of various shapes and sizes with large nuclei. The occurrence of effusion is the exception rather than the rule. Firm adhesion to the costal pleura is more commonly present. Expectoration of tumor cells or tumor masses renders the diagnosis certain. Hemoptysis is not uncommon. The use of a punch to obtain a portion of tissue for examination is rather dangerous on account of bleeding. The subsequent history is that of intrathoracic pressure and rapidly progressive cachexia. Secondary involvement of supraclavicular glands aids in the diagnosis. The physical signs of consolidated lung continue to spread as the disease advances. Operation has not as yet been of benefit in primary carcinoma of the lung.

Sarcoma of the Lung.—Sarcoma of the lung is exceedingly common as a secondary growth. In such cases the diagnosis is not difficult. Primary sarcomata are more rare than carcinomata. Lympho-sarcoma appears to be the most common form. The disease occurs as a diffuse process originating in the lymphoid tissue of the lung in the form of disseminated nodules and areas of tumor tissue following the course of the lymph vessels of the bronchi. The disease is characterized by a rather slow growth and by the formation of secondary tumors, by direct extension, and by metastasis in the abdominal organs. This form occurs with peculiar frequency among the workers in the cobalt mines of Schneeberg, and affects especially the men who have worked continuously for years inhaling the irritating dust of the mines. The tumors often reach a very large size before death occurs. Spindle-celled, giant-celled, and mixed forms of sarcoma are less common, and occur as single nodular tumors of the lung. The signs and symptoms of sarcoma of the lung do not materially differ from those of carcinoma. Stridulous breathing is said to be more common in sarcoma. Breaking down of tumor tissue and expectoration of tumor cells or masses is not likely to occur in sarcoma. Generalized metastasis is more common in sarcoma than in carcinoma. The massive tumors are easily recognizable by means of the X-rays. Death occurs from pressure on the heart, the recurrent nerves, the trachea, from exhaustion, gangrene of the lung, pneumonia, or fatal metastasis, as in the brain.

Benign Tumors of the Lung.—Various forms of benign tumors have been observed from time to time in the lung. Lipoma, fibroma, enchondroma, osteoma, dermoid cysts, endothelioma—the last usually secondary to endothelioma of the pleura. They are to be regarded as pathological curiosities. If large, they may cause dyspnea or other pressure symptoms. Dermoids have been known to burst into the bronchus with the expectoration of hair. There is no means at present whereby a definite differential diagnosis can be made.

THE MEDIASTINUM

A few cases of primary suppuration in the mediastinum have been observed. In most cases infection has been due to wounds and to extension o

suppuration processes from neighboring structures—the neck, the larynx, the trachea, the pharynx, the esophagus, the vertebræ, the pleura, the pericardium, the lungs, and the bronchial glands. (See the Connective-tissue Planes of the Neck and Inflammations of the Neck.) Also from infectious processes of the ribs and sternum; not infrequently from the ulceration of foreign bodies in the trachea and esophagus or to ulceration of a carcinoma of the gullet and as a metastatic process in acute infectious diseases. The inflammations of the mediastinum may be acute or chronic.

Acute Suppurative Mediastinitis.—The most marked SYMPTOM is *pain*, referred to a point behind the sternum, sometimes radiating into the shoulders; or pain in the back, which may follow the course of the intercostal nerves. Tenderness over the sternum indicates rather that the focus is in the anterior portions of the mediastinum; much pain referred to the back, that the tissues in front of the spine are involved. The original focus, if that be known, may point to the seat of the pus.

Fever.—The fever, prostration, and other symptoms of acute sepsis are present.

Pressure Symptoms.—Dyspnea, a sense of oppression in the chest, a rapid, irregular heart action—in some cases a *pulsus paradoxus*, which grows feeble or intermits during inspiration—develop and increase in severity as the pus accumulates and spreads. The abscess may point between the ribs in front, or in the supraclavicular triangle of the neck; and a guide for incision may thus be obtained. In other instances the pus may rupture into the trachea, pericardium, or pleura. Aspirating needles may be introduced in suspected regions. In most cases the situation of the original focus will determine whether the opening is to be made in front or posteriorly, alongside the spinal vertebræ.

Chronic Mediastinitis.—Chronic mediastinitis runs a less stormy course. The pain is less severe, the constitutional symptoms less marked; fever may be absent. The origin of chronic mediasinitis is often in carious tuberculous ribs or sternum, sometimes in tuberculous bronchial glands. Pressure symptoms may be present, as in acute cases.

Tumors of the Mediastinum.—Primary tumors of the mediastinum, whether benign or malignant, are comparatively rare. Secondary tumors are sufficiently common, due to extension from neighboring structures—esophagus, lungs, pleura, sternum, ribs, thyroid gland. The benign tumors produce symptoms by pressure, the malignant tumors by pressure and by the invasion and destruction of surrounding tissues. The following primary benign tumors have been observed in small numbers: lipoma, fibroma, dermoids, echinococcus, retrosternal goiter. The retrosternal glandular masses common in Hodgkin's disease produce the symptoms of mediastinal tumors. Both carcinoma and sarcoma may originate in the mediastinum; they are more numerous than the benign growths; they are believed to originate especially in the remains of the thymus, in the bronchial glands and the walls of the bronchi.

The symptoms produced by the primary tumors of the mediastinum are chiefly those due to pressure. They are dyspnea, from pressure upon the lungs, the bronchi, and trachea; change of voice, from pressure on one recurrent nerve; serious dyspnea, from pressure on both, with paralysis of both

FIG. 239.—ANEURISM OF THE ARCH OF THE AORTA.
(New York Hospital, service of Dr. Frank Hartley.)

vocal cords observable by laryngoscopy; paralysis of the diaphragm, by pressure on the phrenic; a slow pulse, by irritation of the vagi; a rapid pulse, by paralysis of the same; precordial distress and irregular heart action, by pressure on the heart; dysphagia, by pressure on the esophagus. As the tumor grows larger, bulging and deformity of the thoracic wall may occur. The tumor may grow between the ribs and appear externally or, if malignant, infiltrate and destroy these bones and appear beneath the skin. The veins of the front of the chest and back may be dilated. There may be localized areas of edema.

The tumor may appear in the supraclavicular fossa or episternal region. *The trachea may become adherent to the growth, if it be malignant, and the larynx then no longer moves during the act of swallowing.* The lymph nodes at the root of the neck and in the axilla become enlarged in malignant cases. After the tumor has perforated the thoracic wall it may pulsate; such pulsation may be due to its own vascularity or to transmitted pulsation from the heart or aorta. A differential diagnosis from aneurism may be difficult. Evidences of valvular or other heart lesion would favor aneurism; marked displacement of the apex beat, a tumor. The X-rays would show a more or less centrally placed shadow if the tumor were of considerable size.

The *benign* tumors may exist for a long period without destroying life. The *malignant* tumors, by their more rapid and destructive growth, run a much shorter course. The secondary tumors of the mediastinum produce the same symptoms as the primary. They are, of course, all malignant; among them may be included the glands of Hodgkin's disease, carcinoma following cancer of the mamma, and involvement of the mediastinum by tumors of the lung and pleura. Gummata, producing symptoms of tumor in the mediastinum, have been observed.

ANEURISM OF THE AORTA

Aside from ordinary methods of examination lying entirely in the field of internal medicine, the X-rays are a valuable aid in diagnosis. Very good pictures of aortic aneurisms can be obtained, and the shadows cast on the fluoroscope are often distinct.

DISEASES OF THE PERICARDIUM

Effusions into the pericardium may be serous, purulent, or bloody. (For the effusions due to trauma, see Injuries of the Pericardium.) Simple serous effusions occur from profound circulatory disturbances (cardiac and renal disease). Acute inflammatory effusions may be serous, sero-fibrinous, or purulent. They occur as complications of infectious diseases—pneumonia, typhoid fever, acute articular rheumatism, etc. Many are tubercular, and run a more chronic course. (For further details, see works on general medicine.) When the effusion is excessive, or purulent, the condition may be treated surgically with great benefit. The *signs and symptoms* rendering surgical interference desirable are dyspnea; serious interference with the action of the heart, as already detailed under Injuries of the Pericardium; marked increase of heart dullness; the presence of pus, or of pyogenic germs, or the pneumococcus in the effusion, as determined by hypodermic puncture. As in pleuritic effusions, a fluid at first serous may subsequently become purulent. When the effusion contains micro-organisms, free drainage is much to be preferred to puncture.

CHAPTER XXII

THE BREAST

ANATOMICAL AND PHYSIOLOGICAL CONSIDERATIONS

(Partly adapted from Merkel)

The mammary gland reaches its full development only in the female. In well-developed virgins the breast extends upon the thorax from the third to the sixth rib, rarely lower, resting upon, and to a great extent covering, the pectoralis major muscle. The contour of a perfect breast, as viewed from an artistic standpoint, shows no fold at its lower border, and is nearly hemispherical; commonly, gravity causes the lower half to be fuller and rounder than the upper. The nipple is directed a little outward in the virgin. During menstruation the breast usually increases in size; at this time the gland may be a little tender; a subjective sensation of fullness is present. A moderate asymmetry in the size of the two breasts is not uncommon. In females who are poorly nourished or overfat, the breasts are often notably pendant. This is almost invariably the case after a woman has borne a child. The breast does not regain its firm consistence and rounded shape, but remains more or less pendant and flabby.

The skin of the breast is thin and smooth; subcutaneous veins are often visible. After pregnancy, lineæ albicantes, such as occur upon the abdomen, are often to be observed. The skin of the breast is movable over the underlying gland, but during lactation it can no longer be raised into folds. The mobility of the skin is important from a diagnostic point of view. It is early lost in malignant tumors of the breast, as will be noted later. Normally the breast is quite movable on the pectoralis beneath, the fascial attachments being less firm than those to the skin. The skin of the nipple and areola is not smooth, but quite uneven, rough, and ridged. At the apex of the nipple are the minute orifices of fifteen to twenty milk ducts. The areola contains numerous sebaceous and sweat glands. The sebaceous glands produce little prominences on the surface. The color of the nipple and areola is pink and red in blondes and brown in brunettes. This pigmentation is increased during pregnancy and lactation, and is permanent. The skin of the nipple and areola is thin and delicate; nursing easily causes excoriations and fissures, through which infection often takes place, with the production of abscess, erysipelas, etc. The

nipple is permanently increased in size by lactation. During pregnancy from five to fifteen accessory milk glands are developed in the skin of the areola; they form small, rounded or flat prominences in the skin, easily recognized (Montgomery's glands). The nipple and areola contain numerous unstriped muscle fibers; upon mechanical irritation, such as nursing or other, these fibers contract and cause the nipple to become longer and more prominent. The mammary gland is embedded in the subcutaneous fat of the breast. Morphologically the gland is derived from the skin, and probably represents a congeries of sebaceous glands. The gland in well-nourished virgins is separated from the pectoralis muscle by a considerable layer of fat.

The virgin breast is in reality largely composed of fat, the gland itself being quite small and extending only a little way beyond the border of the areola. Its shape is somewhat irregular; sometimes the bulk of the gland lies below the nipple and tapers off above. The milk ducts divide dichotomously, and the ultimate branches end in areas of still imperfectly developed gland tissue. The ducts and lobules remain distinct and do not anastomose one with another. The ultimate branches are surrounded by a considerable quantity of firm connective tissue rich in nuclei, having a hyaline appearance, and different in character from the fibrous supporting stroma between the lobules. On section the gland looks like firm homogeneous connective tissue, which fades off into the surrounding structures; separate lobules cannot be distinguished with the naked eye. On the anterior surface of the gland numerous bundles and planes of connective tissue pass, to be attached to the skin, the spaces between them being filled with fat; beneath the areola there is no fat.

Pregnancy causes the gland to develop its full functional activity. The true secreting acini increase in size and number. The milk ducts dilate, and before their entrance into the nipple considerable fusiform cavities are formed —the "sinus ductuum lactiferorum." The fat and connective tissue are diminished in proportion as the glandular tissue is increased. The lobules of the gland become distinctly palpable, and are readily differentiated on section. Beneath the breast the fat between the gland and the muscle entirely disappears. While the gland assumes a somewhat hemispherical shape, three projections occur on its periphery: an inner, a lower and outer, and an upper and outer; this last reaches to and along the border of the pectoral muscle well up into the axilla in proximity to the axillary lymph nodes, and can be felt as a tender cord extending in that direction. This projection is especially to be borne in mind in relation to inflammations and tumors of the breast. Lactation finished, the breast does not return to its virgin state. The gland remains large, the lobules palpable, and the projection into the axilla is permanent; it should be included in the operative removal of the entire breast. This more or less isolated portion of gland tissue may be the starting point of a new growth. The epithelial lining of the acini of the sometime active gland remains as cylindrical epithelium, and its abnormal proliferation is the starting point of cancer.

Blood Supply of the Breast.—The blood supply of the breast is derived from the perforating arteries of the internal mammary which emerge through the second, third, and fourth intercostal spaces; the second is the largest; and from the long thoracic and acromial thoracic arteries. The deep veins accompany the corresponding arteries. The superficial veins form a network under the skin, and some of them empty into the external jugular above the clavicle. In general, the blood supply is abundant. The individual vessels are not large, but may be enormously increased in size by malignant disease, notably sarcoma.

Lymphatics of the Breast.—The lymph vessels of the breast, and the lymph nodes into which they empty, are of especial interest in relation to malignant disease. The lymph vessels may be divided into two groups: those arising from the gland and those arising from the skin. The lymph vessels of the gland follow the milk ducts; these unite to form a plexus beneath the areola, joined also by the lymph vessels of the skin of the areola and of the nipple. From this subareolar plexus there proceed two large lymphatic trunks, one above, one below the nipple. The first proceeds in a transverse direction toward the axilla; the second describes a semicircular curve downward, to end also in the axilla. From the periphery of the gland above, and below, two smaller lymphatic trunks arise, which join the other two before reaching the axilla. The main trunks empty into the lymph glands situated at the anterior border of the axilla. The first gland lies beneath the border of the pectoralis major, over the third serration of serratus magnus—i. e., over the third rib, sometimes partly over the third intercostal space. A well-developed pectoral muscle may cover it completely. *This gland is commonly the one first infected in carcinoma of the breast.* According to Henle, the axillary lymph nodes are ten to twelve in number. The superficial ones lie immediately beneath the fascia. The deeper ones follow the course of the axillary vein as far as the clavicle.

According to König, "the greater number of the axillary glands are grouped around the origin of the long thoracic and subscapular arteries." A slender mass of fat containing lymphatics lies also in front of and behind the vein. The lymph nodes of the subclavian triangle receive lymph from the axilla, and these become infected, often quite early, in carcinoma of the breast. The deep surface of the breast also has lymph vessels, which communicate with the intercostal lymphatics and thence with the interior of the thorax. Through these channels infection takes place, and masses of carcinoma may be found not only in the substance of pectoralis major, but in the intercostal spaces, quite early in the disease. Hence, the much better results now obtained by operation, since it has come to be a matter of routine to remove both pectoral muscles in all cases of carcinoma mammæ.

Nerves of the Breast.—The nerves of the breast are derived from the supraclavicular nerves which descend in front of the clavicle to supply the skin, and from the anterior and lateral perforating nerves, derived from the in-

tercostals, from the second to the sixth, which supply the deeper portions of the gland.

In childhood and up to the time of puberty the development of the mamma is the same in both sexes. In males the development proceeds no further and atrophy begins at about the thirtieth year. At the menopause the female breast atrophies. There remains nothing behind but milk ducts, connective tissue, and fat. The fat, if abundant, preserves the size and form of the breast.

CONGENITAL ANOMALIES OF THE BREAST

Absence of the mammary gland (amastia) is a rare defect, and when present is commonly associated with other defects in the sexual apparatus. It sometimes happens that the glands remain in an infantile, undeveloped state in the adult female (micromastia). Two nipples may be present on one breast; the nipple may be absent. In males the breasts, one or both, may go on to develop as in women. The condition is known as "gynecomasty," and is sometimes associated with sexual abnormalities, such as undeveloped testis. Occasionally the breasts of female children undergo a precocious development; this may occur alone or combined with an abnormally early development of the entire sexual apparatus. Supernumerary breasts (polymastia) is a not very uncommon condition. One or several aberrant glands may be present; usually there is but one, situated below one of the normal breasts. As many as eight have been observed. They usually occur along a line drawn on the ventral surface of the body from the junction of the upper extremity and the trunk to the genitals, corresponding to the situation of the breast germs of fetal mammals in general. They do not have a complete secretory duct; they may become enlarged and painful during pregnancy. In addition to the above situations, they have been observed on the thigh or hip, on the back, the deltoid region, in the axilla, and elsewhere. Such glands may be large or small, and may be mistaken for benign tumors of various kinds, or for lymph nodes.

INJURIES OF THE BREAST

Open wounds of the breast, whether incised, stab, or punctured wounds, present no peculiarities. The vascularity of the region favors rapid healing in the absence of infection. Contusions of the breast often result in marked extravasation of blood and ecchymosis, which slowly disappears. In not a few cases a blow, a fall, or other similar injury to the breast is followed by the development of carcinoma. Contusions of the breast during the puerperal state and lactation are more apt to be followed by suppuration and abscess than at other times. Burns of the breast are sometimes followed by cicatricial contraction and deformity of the nipple and milk ducts, such that trouble from damming of the milk after labor may occur, and necessitate weaning, or even incision.

DISEASES OF THE BREAST

Diseases of the Nipple and Areola.—During lactation, painful fissures and excoriations of the nipple, notably at its base, are very common; they are readily recognized. Their importance depends chiefly upon the fact that as long as they remain unhealed they form open avenues for infection with pyogenic or other germs. They may become the seat of aphthæ. (See Diseases of the Mouth and Throat.)

Depressed Nipples.—The nipple may form a hollow instead of a projection, and render nursing difficult or impossible, but a very unpromising nipple in a virgin may develop during and after pregnancy into an efficient organ.

Eczema.—Eczema of the nipple and areola, with the formation of crusts, is usually due to want of cleanliness. If chronic, it may end in epithelioma. (See Paget's Disease.)

Syphilis.—Chancre of the nipple usually appears as a juicy-looking superficial ulceration of the nipple, or as an indurated fissure at its base. The history of exposure; inspection of the infant, if the woman is a wet-nurse; the enlargement of the axillary glands; the occurrence of secondary lesions, will establish the diagnosis. If much irritated or infected with pus microbes the chancre may take on an ecthymatous character. Secondary mucous plaques and flat condylomata may occur upon the nipple and areola. (See Syphilis.)

Gummata.—Gummatous ulcerations in the vicinity of the nipple have the same characters here as elsewhere. (See Syphilis.)

Paget's Disease of the Nipple and Areola.—In 1874, James Paget first described a chronic disease of the skin of the nipple and areola which began as a moist, painful eczema with excoriation of the surface, or as a chronic squamous eczema, or sometimes resembled psoriasis. The disease was rebellious to treatment, and was followed, sooner or later, after a year or more, by epithelial cancer of the mammary gland. The disease is a true epithelioma, not a glandular cancer. The growth of the epithelial cells into the deeper structures appears to be due to chronic irritation, as in epithelioma of the lip and elsewhere. The growth is not very rapid; the axillary glands are involved late in the disease. The diagnosis is not difficult after an intraglandular induration has formed. The disease occurs in women between the ages of forty and sixty; the course is slow.

Fig. 240.—Epithelioma of the Nipple (Paget's Disease of the Nipple). (Author's case.)

In a case of my own the woman was aged forty-five. There was a history of a chronic inflammation of the nipple and areola lasting for three years. On examination there was a red, tender, painful, moist, excoriated area two inches and a half in diameter, including the nipple and areola, and extending farther above than below the nipple. The surface was finely granular and bled readily; there was no true ulceration; the borders of the area were sharply marked from the surrounding skin. On palpation the excoriated area was not indurated, but was adherent to the deeper structures. In the substance of the breast there was a hard mass of infiltration, about two inches in diameter, situated, for the most part, above the nipple. An extensive operation was done. Diagnosis.—Epithelioma of the mammary gland. Axillary glands not involved. Patient remained well at the end of five years.

Fig. 241.—Inflammation of the Breast in a Boy; no Apparent Cause. (New York Hospital collection.)

Atheromatous Cysts.—Atheromatous cysts of characteristic appearance sometimes develop in the areola.

Pendulous Tumors of the Nipple.—Pendulous tumors of the nipple in the form of adenoma, fibroma, and angioma have been observed in a few cases.

Inflammations of the Breast.——Inflammation of the breast occasionally occurs in infants a few days after birth; the gland becomes tender and swollen; the skin reddened. A small quantity of clear or milky fluid may be discharged from the nipple. The process usually subsides after a few days; rarely suppuration occurs. In boys and girls at the time of puberty an inflammation of the mammary gland may occur, characterized by swelling, induration, pain, and tenderness. The nipple becomes red and more prominent; there may be a little milky discharge from the nipple and pigmentation of the areola. The process usually ends in resolution, very rarely in suppuration. The swelling and tenderness of the breast during menstruation has already been mentioned. Hemorrhage into the substance of the breast has been observed in cases of irregular menstruation.

Acute Inflammation of the Breast—Acute Mastitis.—We distinguish an acute suppurative mastitis due to infection with pus microbes

and an acute nonsuppurative mastitis due to retention of milk in the puerperal breast. It is to be borne in mind that this distinction is not always easy to make early in the course of these diseases, because, although retention of milk may occur alone, it is also one of the regular or frequent concomitants of puerperal abscess of the breast, and renders the local conditions favorable for infection. Acute suppurative mastitis may occur from infected wounds, from furuncles, or small abscesses of the skin of the breast or areola, or as a metastatic process in pyemia. In the largest proportion of cases it follows childbirth during the nursing period, most often during the first four weeks after labor. The infection takes place through abrasions, fissures, or excoriations of the nipple or areola, and follows the lymphatic channels into the substance of the gland, or through the orifices of the milk-ducts, the bacteria multiplying in the milk, and thence infecting the surrounding structures. The ordinary pus-producing organisms—staphylococcus, streptococcus, colon bacillus, and in a few cases the gonococcus—have been identified in the milk or in the pus. The suppurative process is usually circumscribed, involving a certain limited area of gland tissue, more commonly situated in the lower, or lower and outer, quadrant of the breast. In other cases it is diffuse; the entire gland is riddled with pus foci. In still others a retromammary abscess may exist alone, between the breast and the pectoral muscle, or may be formed by extension of the infection of the gland itself. Occasionally an abscess forms in front of the gland, in the areola, or in the skin; the superficial situation makes the diagnosis simple.

Symptoms.—The symptoms and signs of acute suppurative mastitis, as it ordinarily occurs after labor, are pain, referred to the breast, greatly increased by allowing the child to nurse. As the disease progresses nursing becomes unbearable. Fever, usually high and of a septic type, not infrequently ushered in by a chill. Leucocytosis in varying degree, with a high percentage of large polynuclear cells, is regularly present. On palpation a greater or less area of the breast is found hard, infiltrated, and tender. As the focus approaches the surface the skin becomes edematous and reddened. A doughy, soft, or elastic area indicates the formation of an abscess. Bacteriological examination of the milk is sometimes a useful aid in diagnosis, notably in those cases caused by infection through the milk-ducts and not accompanied by fissures and excoriations of the nipple. Owing to the pain, nursing is impossible, and unless artificial means are used to empty the breast—and this may not be practicable, owing to tenderness or inflammatory swelling of the ducts—the entire breast is swollen, tense, and distended with retained secretion. The occurrence of abscess is popularly attributed to retention of the milk, and doubtless such retention renders the breast more susceptible to infection, but in the majority of instances the infection precedes and causes the retention. In many cases of mammary abscess superficial lymphangitis, with red, tender lines upon the skin running to the axilla, and tenderness and enlargement of the axillary lymph nodes, gives early evidence of the infectious nature of the condition.

Under neglect, or imperfect operative treatment, the infection may spread through a large part of or through the entire gland, so that the whole breast is riddled with purulent foci; further extension may occur, and a large purulent collection form beneath the breast, lifting the gland from the thorax. In these cases the local signs and constitutional symptoms become correspondingly serious and severe. The attack is sometimes grave. In several cases I have seen, as the result of no treatment, or of imperfect operation, fatal pyemia has occurred; in others, entire destruction of the breast, with recovery after amputation of the breast; in others, tedious healing with persistent sinuses, the formation of massive ugly scars and destruction of the gland. Persistent sinuses may remain, from which milk and pus are discharged. It rarely happens from occlusion of one or more ducts that a true milk-cyst of considerable size is produced (galactocele). The presence of a cystic tumor yielding milk, or buttery, oily material on aspiration establishes the diagnosis.

Fig. 242.—Acute Inflammation of the Breast in a Nursing Woman Followed by Abscess. (Author's collection.)

Diagnosis.—In the diagnosis of purulent infection of the breast several practical points should be borne in mind. Superficial abscess in front of the breast is attended by all the signs of acute abscess, and is easily recognized. Deep-seated foci in the substance of the gland give the local signs of one or more tender, painful, indurated areas in the gland and the general symptoms of sepsis. The pain of *intramammary abscess* is intense, sharp, and lancinating. That accompanying *retromammary abscess* is continuous, dull, and throbbing. In these cases the whole breast will feel hot to the examining hand, but localized redness and a sense of fluctuation may be absent, and the surgeon who waits for these signs before affording operative relief subjects his patient to an unnecessary amount of pain and danger. Retention of pus in the wound, continuance of pain, fever, prostration, and leucocytosis usually indicates that

the operative procedures have been inadequate. Retromammary abscess is to be recognized by marked projection of the entire gland from the chest wall and severe constitutional symptoms. On palpation the gland itself may feel normal; lateral compression may not be painful; pressure directed backward causes pain; fluctuation, when present, is usually felt above the superior border of the gland. If the breast is lifted so that the pus sinks down behind the gland the sense of fluctuation may be lost. If the amount of pus is large the gland may be lifted off the thorax, and a sense of fluctuation may be obtained on pushing the entire breast backward against the thoracic wall. The aspirating needle may be used in any case to detect the presence of pus.

Acute Nonsuppurative Mastitis — Retention of Milk — Caked Breast.—This condition as a separate entity apart from an infectious lesion of the breast is not rare. It may occur during the latter days of pregnancy, but is more common during the days following labor; less common during the later period of lactation. The retention is usually confined to a limited area, or areas, of the gland. The affected lobules become tender, painful, and swollen. There may be a little fever, the entire breast is enlarged and engorged with blood. Artificial removal of the milk causes the symptoms to subside. Absence of the local signs of abscess, of intense pain, etc., and of leucocytosis; a sterile condition of the milk and absence of the septic symptoms aid in the diagnosis.

Chronic Abscesses of the Breast.—In a certain number of cases, usually connected with lactation, a circumscribed portion of the breast becomes tender, hard, and painful, but the process stops short of invasion of the skin, softening and perforation. The symptoms subside, and the gland returns to a normal condition, or in other cases a permanent nodular thickening is left behind. In still other cases the acute symptoms subside; the nodule remains and is the seat of some dull pain and discomfort, or causes anxiety merely on account of its presence. Examination of such a nodule shows that the lump is firm or elastic and a little tender. If deeply embedded in the breast, it may give the impression of a solid tumor. Exploration with a needle, or incision, shows a cystlike cavity filled with pus and surrounded by a limiting wall of dense fibrous tissue. Such pus may, or may not, contain living pus germs. I have removed such abscesses which had existed for several years. *Excision*, not *incision*, is the proper treatment.

Chronic Mastitis.—Chronic interstitial mastitis with atrophy of the gland tissue and the production of dense contracting masses and nodules of fibrous tissue in the breast occurs usually near the menopause. The disease is of slow progress, and is attended by moderate pain and discomfort; the gland is diminished in size; nodular masses and cords of dense fibrous tissue are palpable in the breast, sometimes extending toward the axilla. In some cases the nipple may be retracted; the gland remains movable, the axillary glands are not enlarged. Many of these cases end in carcinoma; nor is a differential diagnosis possible without a careful microscopic examination

of sections of the indurated tissue. Solitary or multiple cystic dilatations of the milk-ducts may occur in these cases from obstruction of the ducts and retention of their secretion; such cysts may attain the size of a hen's egg.

Chronic Cystic Mastitis (*Cystadenoma mammæ*).—The exact pathology of this disease is variously explained by different observers. By some it is regarded as distinctly an inflammatory process; by others rather as a new growth than as an inflammation. (Schimmelbusch) Cystadenoma mammæ.

Schimmelbusch describes the lesion as follows:

The primary changes are not a dilatation or closure of the glandular ducts, but a proliferation of the epithelia of the acini, without any evidence of increase in the number of nuclei, or cellular infiltration of the connective tissue. The acini are entirely filled and dilated by the epithelial growth. By the subsequent degeneration of this epithelium a cavity or cyst is formed.

Sasse considers that the formation of cysts may occur in two ways: by multiplication of epithelium, as described by Schimmelbusch; and by an interstitial mastitis with pressure upon and dilatation of the glandular ducts. (For other views the reader is referred to special works on surgical pathology and to monographs by W. Mintz, Roloff, and Tietze.)

Clinical Characters.—The disease is characterized by the formation of smaller or larger cystic cavities in the breast, containing clear, colorless, or greenish-brown fluid, and by dilatation of the milk-ducts. The fibrous stroma of the breast is swollen and infiltrated with round cells. The cavities vary in size from the head of a pin to that of a pigeon's egg, and in fully developed cases are scattered everywhere throughout the substance of the gland. The disease is frequently bilateral. It may develop at any time after puberty, and appears to be more common among women who have borne children, but have not nursed them. There is commonly a history of a painful swelling of one or both breasts during menstruation; afterwards the pain and swelling may subside, but one or more tender nodules remain behind; this process is repeated from time to time. According to König, the following is a typical picture of the condition:

On palpation with the finger tips the disseminated nodules can be distinctly felt, notably if a portion of the breast is lifted away from the chest between the finger and thumb. Upon pressing the breast against the thorax with the palm of the hand no nodules are distinguished, and it is sometimes necessary to grasp the breast in some particular direction in order that they may be felt. The nodules are smooth, tense, or elastic, sometimes distinctly fluctuating, and are seldom as large as a pigeon's egg.

In my own experience they often feel the size and shape of buckshot and quite hard. Pressure upon the nodules sometimes causes the escape of clear, milky, or brown-colored fluid from the nipple. The skin does not become

adherent to the gland, nor the gland to the underlying muscle and fascia. The axillary glands are not enlarged. These characters, together with the increased pain and swelling during menstruation, the slowly progressive manner in which the disease gradually occupies the entire gland, the fact that both breasts are often involved, and the characteristic multiple nodules in the breast, render the diagnosis clear in well-marked cases.

In some cases proliferation of the epithelium lining the cyst walls may occur with the formation of considerable tumors, and increase in the pain and discomfort. Cancerous degeneration is not infrequent. Operative removal of the entire gland is desirable when the patient is over thirty-five years of age, when much pain and discomfort are present, and in cases where the mind of the patient dwells upon the condition of the breasts. Opinions differ among surgeons as to the radical treatment of milder cases. Personally, I believe the condition a threatening one, which justifies removing the breast. I have several times found beginning cancerous changes in cases believed to be quite innocent. There are also combinations of cystic mastitis and the chronic interstitial sclerosis of the breast (chronic interstitial mastitis). In these cases one or more cystlike cavities exist in the dense fibrous stroma of the atrophic breast.

Tuberculosis of the Mamma.—Primary tuberculosis of the mamma is a rare disease. The infection may occur through the blood or, apparently, through the milk-ducts. Tuberculosis of the breast as an extension from tuberculous caries of the ribs, sternum, or pleura is not uncommon. Primary tuberculosis of the breast is more frequent in women than in men. It does not occur before puberty and very rarely in old age. Associated tuberculous lesions are common; the axillary glands are often involved. The disease may occur as an isolated lesion with the production of a solitary cold abscess, or as a disseminated process with multiple foci, which undergo degeneration with the formation of multiple tuberculous abscesses and fistulæ. Further, as a diffuse submiliary tuberculosis of the entire gland, including the nipple.

The diagnosis of tuberculosis of the breast is easy if tuberculous sinuses or ulcers are present, the appearances being quite typical. In other cases the diagnosis will rarely be made without operation. In the case of a solitary cold abscess there will be the history of a slowly growing tumor in the gland; little or no pain or tenderness; a tense and elastic or fluctuating nodule will be felt in the breast, rarely surrounded by a dense layer of infiltrated tissue. Incision permits the escape of typical tuberculous pus and cheesy material; the cavity is lined by typical tuberculous granulation tissue. In the disseminated and diffuse form numerous nodular masses will be felt in the breast, of varying size and consistence. The nipple may be retracted, but the breast is movable on the pectoral muscle, or, more rarely, adherent. The axillary glands are often enlarged and hard or broken down and fluctuating. The condition is evident on incision in many cases; in others the diagnosis has only been made after microscopical examination of the diseased tissues. Both the solitary and

disseminated forms are characterized by an extremely chronic course; the nodules may exist for years without invasion of the skin. In some cases the disease makes more rapid progress; the nodules become confluent; abscesses and sinuses form. The axillary glands are involved in a large proportion of cases, and the process in the glands is apt to be more rapid, so that the focus in the breast, being painless, might not attract attention. In some cases a palpable cord of infected tissue has been noted passing from the breast to the axillary glands.

Diffuse Miliary Tuberculosis of the Breast.—Diffuse miliary tuberculosis of the breast is a rare lesion. The following case from my own experience is perhaps worthy of record:

The patient was a large, well-nourished woman, forty-two years old, the mother of several healthy children. There was no tubercular history in her own life. For several years she had noticed a lump in the left breast, which had slowly increased in size, giving no symptoms other than those due to its mechanical presence, a sense of weight and fullness in the breast, and a little dull pain from time to time. Two months before I saw her the breast had commenced to grow larger quite rapidly. It had become tender and somewhat painful; these symptoms were steadily getting worse. On examination the breast was notably and symmetrically enlarged; the skin over the entire breast was slightly reddened and edematous, and immovable over the gland; the nipple was swollen and unduly prominent. On palpation the breast was occupied by a hard, dense tumor; the general outline of the tumor was rounded, and appeared to be covered by a layer of inflamed and infiltrated skin and glandular tissue. The tumor was movable upon the pectoral muscle; the axillary glands were enlarged, a little tender, and soft, rather than hard. The patient had a slight rise of temperature every evening.

The diagnosis was made of a benign tumor which had undergone a malignant degeneration, of a character not entirely clear. A large portion of skin, the breast, the pectoral muscles, and axillary contents were removed in one piece. The patient made a complete recovery and continued in good health. Pathological examination showed the tumor of the breast to be a fibro-adenoma. The nipple, the areola, the skin and subcutaneous tissues overlying the breast, the gland itself throughout, was the seat of an acute submiliary and miliary tuberculosis. None of the tubercles was larger than a No. 10 shot. The axillary glands were the seat of an early acute tuberculosis; there was no evidence to show that they had been primarily infected.

Actinomycosis of the Breast.—Actinomycosis of the breast is an extremely rare localization. The disease presents itself in the guise of a subacute inflammation of the breast with formation of hard nodules, which later form abscesses. The characteristic granules establish the diagnosis. The ribs and pleura may be involved, and dissemination of the disease is not improbable. The method of inoculation in the recorded cases could not be demonstrated.

Gummata of the Mamma.—The diagnosis of gumma of the breast is easy in the presence of a crateriform ulcer lined with gummy material. In other instances the presence of a hard or elastic painless nodule in the breast, of slow or moderately rapid growth, which came to be fluctuating without notable increase in size, and without any of the concomitants of malignant disease, might lead to the use of iodid internally; improvement or cure of the tumor would establish the diagnosis. Upon incision, the absence of cheesy pus and of a lining membrane of tubercle tissue, together with the typical appearance of gummy material, would usually prevent error. A diffuse syphilitic mastitis has been described. Here, as elsewhere, the history and other evidences of syphilitic infection are important.

Neuralgia of the Breast.—Mastodynia occurs chiefly in neurotic and hysterical females, and in those subject to intercostal neuralgias. Fear of malignant disease is often present; the breast is usually normal in appearance. Shooting pains are complained of in the breast, the side, the inner surface of the arm, and the shoulder. Physical examination shows extreme sensitiveness on palpation, often hyperesthesia of the skin; the breast may appear a little enlarged; a mastitis of one or more lobules, or a neurofibroma, may be palpable, or nothing may be found. The pain and hyperesthesia are usually worse during menstruation. Uterine and adnexal disease should be excluded.

Hypertrophy of the Breast.—Great enlargement of the breast may be a true hypertrophy of all the structures, including the gland tissue. Such unusually large breasts may occur in virgins, but are more common during pregnancy. After lactation is over they may greatly diminish in size. These breasts do not grow to enormous proportions, and do not necessitate surgical operations. The occurrence of such hypertrophies is most unusual. Another variety, more common, but still exceedingly rare, is a diffuse fibro-lipoma of the breast, in which either the fat or the fibrous tissue may predominate; scattered glandular tubules and imperfectly developed acini are found in the growth. In these cases the true glandular substance undergoes atrophy; in some cases cysts are formed. Usually both breasts are involved, first one, then the other; in a few cases but one breast becomes enlarged. The growth occurs in young women and girls either at puberty or later, often during pregnancy. The increase takes place rapidly, and may reach a large size in a few months. It is said that the growth is always intermittent. Successive accessions in size, following at irregular intervals, or as the result of pregnancy.

At first the growing breast is firm and prominent, soon it becomes flaccid and pendent; the skin remains normal, but may become edematous; dilated subcutaneous veins are apparent; the areola is increased in size, the nipple flattened. The breasts may reach to the pubes, or lower, and each breast may weigh many pounds; breasts of twenty to thirty and forty pounds have been recorded. The patients suffer much discomfort from the enormous size of the breasts; they may be unable to walk; the breasts require some artificial support, such as a table, to enable the patient to sit up. They become anemic and

may suffer from dyspnea. Slight traumatisms may cause ulceration and sloughing of the breasts; erysipelas has destroyed life in several cases. In the event of pregnancy, the increase may be very rapid and attended by much pain, and even alarming symptoms of exhaustion, due to the failure of general nutrition.

TUMORS OF THE BREAST

General Considerations and Statistics.—Tumors of the breast occur with great frequency in the female; less commonly in the male. In the female breast almost every variety of benign and malignant growth has been observed. The malignant growths constitute nearly ninety per cent of all tumors of the breast; of these, eighty per cent are carcinomata; the sarcomata vary in the statistics of different clinics between six per cent and nine per cent, leaving a little more than ten per cent only of benign growths. Among the benign growths, the fibro-adenomata are much the most frequent. Pure fibroma and pure adenoma are surgical rarities in this locality.

Benign Tumors of the Breast.—Fibro-adenoma.—These tumors present themselves in a variety of forms, according to the relative growth and to the arrangement of the fibrous stroma and of the glandular substance respectively. In some cases the dense fibrous stroma is greatly in excess, in others the glandular substance; in consequence, the growths are harder or softer, as the case may be. The following description of the varieties of fibro-adenoma of the breast is adapted from Schimmelbusch: In some cases the glandular tubules increase in length and breadth, as do the acini, but remain flat and narrow, with the production of slit-like cavities in the tumor lined with cylindrical epithelium. This mode of growth may give the tumor the appearance of being made up of thin layers of fibrous tissue separated by narrow clefts. The formation and retention of a mucoid secretion in the alveoli may lead to the formation of cysts (cysto-adenoma). An irregular growth of the fibrous stroma may cause projections and polypoid or flat excrescences in the dilated acini (intracanalicular fibroma, cystosarcoma proliferum). Myxomatous degeneration of the stroma renders the tumor softer; this condition may be combined with proliferation of the glandular epithelium or with the cyst formation (cystosarcoma phyllodes, in-

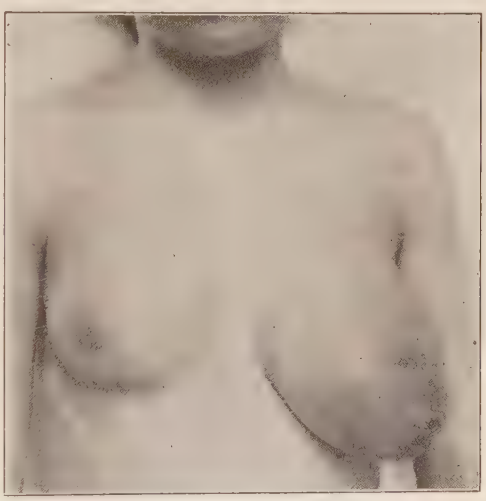


Fig. 243.—Fibro-adenoma of the Breast in a Young Girl, Aged Fourteen. (Author's collection.)

tracanalicular myxoma). These distinctions are rather of interest to the pathologist than to the surgeon, and are not of great clinical importance, except that they cause the tumor to be hard or soft, or to vary in consistence in different portions of the same growth.

Clinically, upon section, the fibro-adenomata are grayish-white in color, of homogeneous texture, except when cysts are present. They are often distinctly lobulated; the fibrous layers are sometimes arranged concentrically like the several layers of an onion. The consistence is more or less firm, according to the greater or less development of fibrous stroma or of glandular elements. Myxomatous degeneration causes the tumor to become notably soft, sometimes almost semifluid. The growth is surrounded by a distinct fibrous capsule. The fibro-adenomata occur for the most part in young women, rarely after the fortieth year of life. They are painless, distinctly movable in the breast, from which they may even appear to be detached; they do not become adherent to the skin nor ulcerate; the axillary glands are not enlarged. The tumors vary in size from a walnut to that of a child's head, such large tumors being rare. They usually grow quite slowly; they are smooth, rounded, or lobulated in contour, usually firm, although harder and softer places may alternate in the same growth after the tumor has grown to considerable size and has undergone mucous or cystic degeneration. Large tumors may give rise to disagreeable symptoms by weight and pressure. Rarely the circulation of the tumor may be imperfect, so that necrosis of the entire tumor takes place; infection and abscess of the breast is the usual cause of this event.

FIG. 244.—FIBRO-ADENOMA OF THE BREAST OF LARGE SIZE. (Collection of Dr. F. W. Murray.)

It is to be borne in mind that the fibro-adenomata of the breast, notably those in which the epithelial elements predominate, may, after having existed for years, undergo carcinomatous degeneration. The early removal of these tumors is, therefore, indicated in every instance.

CYSTOSARCOMA OF THE BREAST (CYSTOSARCOMA PHYLLODES, CYSTOSARCOMA PROLIFERUM).—It is customary to distinguish under one of the above titles a not very uncommon tumor of the female breast having peculiar clinical features, differing from ordinary fibro-adenoma of the breast on the one hand,

and from typical solid sarcoma on the other. The true pathological position of this growth is perhaps not definitely fixed. Under the name cystosarcoma phyllodes it was first described by Johannes Müller. The tumor is really one of the varieties of fibro-adenoma, characterized, however, by a tendency to undergo sarcomatous degeneration.

The tumors occur a little later in life than do the ordinary fibro-adenomata. In thirty-five cases collected by Gross the average age was 33.7 years. In their early stages they are not to be differentiated clinically from ordinary fibro-adenoma, and may remain small for a long period and suddenly take on a rapid growth. They often attain a considerable size, so that the entire breast is occupied by the growth and forms a large pendent mass. The tumor retains a connective-tissue capsule throughout, and while small is freely movable. Lymphatic infection, metastasis, and cachexia do not occur. The skin is very rarely involved, but may, very late in the disease, become adherent, edematous, and even ulcerated. The subcutaneous veins may be dilated, the tumor is of uneven surface, and often covered by rounded cystic knobs; in other places hard areas are present. There may be a mucoid or serous discharge from the nipple. These tumors never become adherent to the pectoral fascia or muscles. Only in rare cases is the nipple retracted. On gross examination the tumor is white or reddish in color, and of uneven consistence, firm and soft or fluctuating areas are present here and there. Section of the tumor shows irregular cystlike cavities containing mucoid, rarely blood-stained fluid, occasionally pearl-like masses of epithelium. Papillary outgrowths and flat projections, covered by layers of proliferating cylindrical epithelial cells, project into the cavities, and partly fill them. The stroma in spots is in a state of mucous degeneration or is edematous, in other places fairly firm, but densely infiltrated with round cells; areas of spindle cells may also be seen. True sarcomatous degeneration may, as stated, occur.

Pure myxoma of the breast, except as the result of mucous degeneration of a fibro-adenoma, is exceedingly rare. Clinically the two cannot be differentiated. *Lipoma* of the breast is nearly always a retromammary tumor which pushes the gland prominently forward. The slow growth and elastic character of the growth render the diagnosis not difficult. Chondroma is a very rare tumor of the breast, and the same is true of osteoma. Such tissues may occur in mixed tumors of the gland, usually sarcomata, sometimes in carcinomata. Typical atheromatous cysts and cholesteatomata of the breast have been observed in a few cases. The cysts are of slow, painless growth, form smooth elastic rounded swellings containing characteristic contents.

Malignant Tumors of the Breast.—Sarcoma of the Breast.—All the forms of true sarcoma may occur in the breast. (See Sarcoma.) As stated, they are far less frequent than carcinomata. Here, as elsewhere, the soft, rapidly growing, round-celled, medullary, and melanotic sarcomata are the most malignant, the latter being fortunately rare. The spindle-celled firm tumors are less malignant. Sarcoma of the breast may occur at any age. The spindle-celled

and so-called cystosarcoma are rather more frequent during the period of functional activity of the breast. The more malignant forms more commonly occur during or after the menopause. In their early stages it is quite impossible by external palpation to distinguish the sarcomata from other forms of tumor in the breast. They form nodular masses, usually solitary, often encapsulated, and at first movable. Of any possible degree of hardness or softness. The harder forms may be mistaken for fibroadenoma, if movable; for carcinoma, if attached; for cystic tumors, if very soft. As they increase in size the distinctive characters of sarcoma become more marked. They are painless tumors. The more benign forms grow slowly and are hard; the more malignant rapidly, and soon become soft. They sooner or later infiltrate and become adherent to surrounding structures. They rarely ulcerate until late in the disease. The softer forms are often very vascular tumors and may pulsate; dilated veins are to be noted on the surface. The axillary glands are secondarily involved only in rare cases and late. There may be a serous or bloody discharge from the nipple. Dissemination takes place rather by the blood current; and secondary growths in the lung, liver, bones, brain, and elsewhere are common. Cachexia is present in the late stages. The clinical signs and symptoms are, as will be seen, quite different in well-developed cases from carcinoma.

Fig. 245.—Ulcerated Sarcoma of the Breast. (Collection of Dr. Charles McBurney.)

Fig. 246.—Ulcerating and Fungating Sarcoma of the Breast; Inoperable.

Carcinoma of the Breast.—As already stated, about eighty per cent of all tumors of the breast are carcinomata. They occur in all countries and

among all peoples, but are said to be more frequent among the white than the dark-skinned races of mankind. There seems to be no doubt but that the number of recorded deaths from cancer has steadily increased during the past fifty years. The increase appears to keep pace to some extent with the material prosperity of a community, and the theory has been advanced that more luxurious living, and especially abundance of nitrogenous food, bears a direct causative relation to the increase. As stated under Tumors, the active agent in the production of cancer remains undiscovered. Cancer of the breast is, generally speaking, a disease of middle and advanced life. In seventy cases coming under my observation the average age was fifty years. It is occasionally observed in women under thirty years of age; and in these cases runs a particularly malignant course. When cancer of the breast is complicated by pregnancy the growth is especially rapid and the prognosis unfavorable. Various predisposing causes of cancer of the breast are local trauma, chronic irritation—as in Paget's disease, already described under Epithelioma of the Nipple. Preëxistent inflammations, either acute, suppurative, or chronic, predispose to the formation of cancer. The nursing of several infants in succession, the existence of benign tumors of the breast which undergo cancerous degeneration, notably fibro-adenoma, account for a certain proportion of cases. In the male breast cancer is a rare disease, the proportion of males to females being about 1 to 100. Various forms of cancer occur in the breast, the varieties depending largely upon the relative proportion of cellular elements and fibrous stroma. Those cancers which contain much fibrous tissue and but few alveoli are hard tumors of slow growth. Those which contain many large alveoli and many cells with but little fibrous stroma are soft tumors, and usually grow rapidly.

Billroth divided carcinoma of the breast into four types:

1. *Acinous Cancer.*—The structure of the tumor conforms more or less perfectly to that of an acinous gland. It occurs in the breast as a nodular tumor, rather soft than hard, of a grayish-white or reddish-gray color on section; from the surface the characteristic cancer juice can be expressed or scraped. The alveoli are quite large, the stroma is moderate or small in amount, and densely infiltrated with small round cells. The softest of these tumors are sometimes spoken of as *medullary carcinoma.* (The author sees no reason why they should be placed in a separate group.) The tumor is prone to grow rapidly; to undergo degenerative changes early; to invade the skin; ulcerate and produce fungating masses of tumor tissue, or sloughing putrid craterlike ulcers. Infection of the axillary lymph nodes occurs late, as does constitutional infection. The secondary tumors resemble the primary growth. The prognosis of this form of cancer is not very unfavorable. The experience of William S. Halsted upholds this view. He considers the prognosis of these cases better after operation than in Types 2 and 3.

2. *Carcinoma simplex—Tubular Cancer.*—Carcinoma simplex—tubular cancer—is the most frequent form of cancer of the breast. It is characterized by

greater hardness than the acinous form, by a tendency to rapid infiltation, especially of the skin and subcutaneous tissues, and the formation of multiple scattered hard nodules in the skin, which coalesce and produce a boardlike hardness of the soft parts covering the chest wall, to which the infiltrated tissues are firmly adherent ("cancer en cuirasse"). Ulceration and retrogressive changes in the tumor tissue (fatty metamorphosis) are common. The arrangement of the alveoli is often in the form of long, slender strings of cancer cells; in other places oval, rounded, or irregular spaces exist in the stroma, filled with tumor cells.

FIG. 247.—SCIRRHOUS CARCINOMA OF THE BREAST, SHOWING ATROPHY OF THE BREAST AND RETRACTING OF THE NIPPLE. (New York Hospital, service of Dr. Frank Hartley.)

3. *Scirrhous Carcinoma.*—Scirrhous carcinoma has been sufficiently described under Tumors.

4. *Colloid Cancer.*—Carcinoma gelatinosum is a rare form of the disease. The tumor is of slow growth and not markedly malignant. It is characterized by a slimy degeneration of the stroma. This degeneration may occupy the entire tumor or only the older portions. In some cases the contents of the alveoli undergo fatty or calcareous degeneration, the epithelia disappear. The tumor is soft, juicy, friable, semicystic.

Adenocarcinoma. — Under the head Adenocarcinoma, W. S. Halsted described a form of cancer of the breast characterized by the production of a prominent tumor mass tending at times to become nearly pedunculated. Ulceration and the formation of fungating granulations are common. The alveoli of the tumor are large and the cells occupy their periphery, being usually absent from the centers. Infection of axillary lymph nodes occurs late, or not at all. The growth is not very malignant. Halsted considers this growth identical with the duct cancer of the English and with the villous cancer of the French.

Clinical Course and Diagnosis of Cancer of the Breast.—The first symptoms noticed by the patient may be intermittent, sharp, lancinating pain felt in the breast, radiating to the shoulder and arm. In other cases a nodule is discovered by accident in the breast; this may have already attained some size. The nodule is situated in the substance of the gland, and may occupy any

position. The periphery of the upper and outer quadrant is its site in more than half the cases. Upon palpation the lump is felt to be of rather uneven outline, usually hard, rarely soft, and intimately adherent to the structure of the gland. One of the most characteristic signs of cancer of the breast is flattening or retraction of the nipple, caused by contraction of the fibrous stroma of the cancer, involving the walls of the milk-ducts and their lymphatics. Of this sign it is to be remembered that it is not pathognomonic of cancer, since a former abscess of the breast or interstitial mastitis may produce it; nor is its absence of any special value in the exclusion of cancer. In some cases a dimple will appear in the skin of the breast from a similar cause, or the skin will be wrinkled over a larger or smaller area. In very early cases the attachment of the fibrous bundles of subcutaneous tissue to the tumor will only be appreciated by attempting to move the skin over the tumor, when slight puckering or wrinkling of the skin will be observed. Adhesion to the glandular structure itself is readily made out by grasping the tumor with the fingers and attempting to move it. The commonest form of benign tumor—one or other of the varieties of fibro-adenoma—will be felt to slip about quite freely in the substance of the gland, or even to be quite detached from it. If the growth is cancer, gland and tumor move as one mass. Many cancers of the breast form adhesions to the pectoralis fascia quite early; others only after they have existed for many months. The presence or ab-

Fig. 248.—Scirrhous Carcinoma of the Breast Extending Upward and Outward, Showing Characteristic Atrophy and Puckering of the Skin. (Roosevelt Hospital, collection of Dr. Charles McBurney.)

Fig. 249.—Ulcerated Adenocarcinoma of the Breast. (Collection of Dr. Charles McBurney.)

sence of such adhesions is best appreciated by abducting the arm to the horizontal position, thus putting the pectoralis major a little upon the stretch, grasping the breast with the whole hand and attempting to move it back and forth in the direction of the fibers of the pectoralis major muscle. If no adhesions are present, the movement will be free; if the growth is adherent, a sliding movement will be limited or absent. If the growth is already adherent to the thoracic wall (sternum or ribs), it will be immovable, irrespective of the position of the arm.

FIG. 250.—ADENOCARCINOMA OF THE BREAST. (Collection of Dr. Charles McBurney.)

The axillary glands become infected and palpable after very variable periods in cancer of the breast; in some cases in a few months, in others not for a year or more. I have seen cases of atrophic scirrhus of the breast in which the glands remained unaffected for years. Because the glands are not palpable, it is not to be concluded that they are not diseased, since it has been shown by Halsted that they may be the seat of carcinoma in a few weeks after the discovery of the tumor. The first gland to be affected is usually the one situated beneath the border of the pectoralis major, over the third rib or third space. Palpation of the axilla to detect such glands is best made with the arm hanging by the side. The nodules, if cancerous, are hard and insensitive. Early they are small and movable; they may escape detection if the patient is fat. Later they become large and fixed to the ribs or to the vessels; they then form stony immovable masses, of absolutely bad omen. It is well in every case to examine both axillæ. Late in the disease pressure upon the nerve trunks of the axilla causes horrible, torturing pain, and weakness of the arm. Pressure upon the axillary vein, hard edema of the hand and arm. Involvement of the supraclavicular and cervical glands occurs after those in the axilla. If they are palpably enlarged, the prog-

FIG. 251.—CARCINOMA SIMPLEX OF THE BREAST, SHOWING RATHER MASSIVE TUMOR AND RETRACTION OF THE NIPPLE. (Collection of Dr. Charles McBurney.)

nosis is very unfavorable for cure. The increase in size of the tumor itself varies with the variety of cancer. The soft cellular forms grow rapidly and may attain a considerable size in a few months. Scirrhus grows slowly, and instead of an increase the whole breast may show a decided diminution in size. The involvement of the skin varies much in different cases. In the soft acinous cancers it is early adherent and boggy, then reddened and rapidly ulcerated, with the production of a crateriform ulcer, with a sloughing, often putrid, base; or the formation of a fungating bleeding mass of granulation tissue.

In carcinoma simplex multiple nodules are often formed in the skin of the breast and the vicinity—a sign of very bad omen. In this form, also, ulceration is frequent. In scirrhus it is usually long delayed and superficial. The condition known as "cancer en cuirasse" is especially common in carcinoma simplex, although it may occur in any of the forms of the disease if the patient survive long enough. Cancerous nodules appear in the skin of the breast, the axilla, over the sternum, and, later, are scattered over the entire thoracic wall, front and rear. A dense boardlike infiltration steadily advances from the tumor in the breast in all directions. New nodules appear, and finally coalesce until a half or more of the thoracic wall is a solid mass of cancerous infiltration.

FIG. 252.—ULCERATED CARCINOMA OF THE BREAST, INOPERABLE. (New York Hospital Collection, service of Dr. F. W. Murray.)

The regular history of cancer of the breast is that of steady progress. The tumor tissue invades, infiltrates, replaces, and destroys the surrounding tissues without regard to their character; at the same time lymphatic infection goes on to the axilla and to the pectoral muscles, the intercostal spaces, the sternum, and the pleura. Dissemination through the lymph channels and blood current causes secondary tumors in distant regions—the liver, the spine, the bones, the brain, etc. Retrogressive changes in the primary tumor lead to the absorption of toxic products, to ulceration, chronic sepsis, and hemorrhage. In many cases there is produced, quite early in the disease, before any secondary tumors can be found, a notable change in the general health; the patients become anemic and have a peculiar waxy pallor; they feel weak, suffer from impaired digestion, emaciation is often absent until very late. As the disease progresses, pain, sepsis, hemorrhage, and the symptoms produced by the secondary tumors

gradually destroy life—sometimes by exhaustion, usually by a combination of the causes mentioned.

Practical Suggestions.—In regard to the diagnosis of tumors of the female breast in general, a few words may be added of a practical character. Cancer is much the most frequent tumor of the breast. Any tumor appearing in the breast in a woman forty years of age or more is probably a cancer. A tumor which has remained small for years and then begins to grow rapidly, has almost certainly undergone malignant degeneration. Experience shows that many benign tumors undergo such changes, notably at the time of the menopause. A tumor of the breast of any sort at any age is a source of discomfort and anxiety to its possessor, as well as a possible menace to life, and should be removed by operation, unless distinct physical contraindications exist. In the case of a tumor, the nature of which is doubtful, temporizing measures are absolutely inexcusable on the part of a medical attendant. The proper diagnostic measures to pursue in such cases are incision and inspection of the tumor. If doubt still remains, removal of a small portion; examination of a frozen section, then and there, and an operation in accord with the findings of the pathologist. By early and thorough operation the prognosis of cancer of the breast has been greatly improved during recent years. A positive diagnosis of every tumor of the breast is therefore desirable at the earliest possible moment.

Contraindications to Operation.—In what cases should we refrain from operating for carcinoma of the breast? Atrophic scirrhus of the breast in very old and feeble women may well be let alone; the disease may exist for years without destroying life, or even exposing the individual to great suffering. The presence of metastatic tumors, or of marked cachexia, indicates that an operation would be useless. Large immovable nodules in the axilla, the presence of a cancerous boss upon the sternum, matted carcinomatous lymph nodes in the neck, indicate hopeless conditions. Extensive infection of the skin and the presence of secondary cancerous nodules around the primary growth render the prognosis unfavorable, and may be distinct contraindications. In a general way, when it seems possible to remove the entire disease, we should operate, otherwise not. As a palliative measure superficial ulcerating growths which can be removed in their entirety, may, sometimes, be so removed, with temporary benefit, though we know that in other directions the disease is beyond our reach.

Tumors of the Male Breast.—The occurrence of tumors of the breast is a hundred times more frequent in women than in men, and of the tumors of the male breast only a small percentage are carcinomata. Of benign tumors, fibro-adenoma, cystic adenoma, submammary lipoma, as well as tuberculosis and gumma may occur. Carcinoma develops between the ages of forty to sixty years in most cases. The disease does not differ in any essential from what we find in the female.

CHAPTER XXIII

THE ABDOMEN

The diagnosis of the injuries and surgical diseases of the abdomen is one of the most interesting, and sometimes one of the most difficult, tasks the surgeon is called upon to perform. The responsibilities in the given case are often heavy, since the life of the patient may depend, both in injury and disease, upon the immediate decision of the question, Shall the abdomen be opened or not? In some cases the answer is easily arrived at; in others, a high degree of skill and judgment based upon a wide experience are called for to arrive at a correct decision; and in still others, the best men alive may err. In abdominal diseases, the patient will usually have been in charge of a medical man, who furnishes the history of the case and frequently the diagnosis. The choice, for or against operative interference, rests with the surgeon. Time was when a large proportion of the medical profession shared with the laity a decided fear of and prejudice against early operative interference in diseases of the abdominal organs. The good results following early operation in many acute and chronic abdominal conditions, together with the dangers of delay, and the utter hopelessness of interference when malignant disease is far advanced, or the patient is exhausted by septic poisoning or by diffuse purulent peritonitis with paralysis of the intestine, are now very generally recognized by the more intelligent members of the medical profession, and even by the laity. The surgeon may therefore expect to be called at a favorable time, and to receive hearty support from the family medical attendant in a large proportion of the cases he is asked to see. Many cases are met with such that the surgeon, although ignorant of the precise seat and nature of the lesion, is entirely justified in operating on the ground that the disease is evidently of a serious character, only to be relieved, if at all, by operation, and that the risk of exploration is slight. The various forms of intestinal obstruction, cases of acute purulent peritonitis of obscure origin, many injuries of the abdomen, a considerable number of abdominal tumors, and numerous other conditions may fall into this category. Before describing the methods used in the diagnosis of intra-abdominal lesions, it will be necessary to discuss the injuries and diseases of the abdominal wall. Lesions of the viscera and of the parietes are often associated, but many of the latter occur alone, and demand, therefore, separate consideration.

INJURIES OF THE ABDOMINAL WALL

Injuries of the abdominal wall may be subcutaneous or open wounds; the latter may be penetrating or nonpenetrating.

Contusions.—The slightest form of contusion occurs from slight or moderate blows upon the abdomen, and is followed by the escape of blood into the subcutaneous tissues, ecchymosis, slight pain, and tenderness. These signs and symptoms usually disappear in a few days. If a considerable vessel or several vessels are ruptured, a fluctuating hematoma may form beneath the skin. The effused blood tends to spread by gravity, and to appear as a characteristic blue discoloration on the lower part of the abdomen, the thighs, the flanks, and sometimes upon the back. In some cases, when the violence is more severe, bleeding may take place behind the abdominal muscles in the properitoneal fatty tissue. In these the blood may find its way downward, and appear after several days below Poupart's ligament in the thigh; such bleeding may be large in amount.

Shock.—After severe contusions of the abdomen, the condition known as abdominal shock is observed; the symptoms are believed to be due to irritation of the peripheral nerves, causing a reflex paralysis of the vasomotor center of the medulla. The patients fall immediately into a condition of collapse. The features are pale, drawn, and pinched; the mucous membranes are blanched, the expression dull and apathetic. Cerebration is slow and imperfect. The pupils of the eyes are dilated, and respond but slowly to light. The extremities are cold. There may be nausea and vomiting. The temperature of the body is often subnormal, the pulse slow or rapid, thready, and compressible. Respiration is shallow, irregular, or sighing; it may be of the Cheyne-Stokes type. (See Shock.) From this condition the patients usually rally after minutes or hours, unless some gross lesion of the abdominal contents is present. A few cases only have resulted fatally, apparently from the condition of shock alone, death being preceded by unconsciousness and progressive heart-failure. All these cases give the surgeon anxiety and demand careful watching for signs of intra-abdominal bleeding or injury of hollow organs.

Still another condition occurs from blows upon the upper part of the abdomen and over the lower ribs, the nature of which is not entirely clear. An individual receives a blow in the epigastrium—as from a fist while boxing. He falls to his knees or prone upon the ground, and for some seconds is almost unable to breathe; there is a sense of impending suffocation. The expression of the face is drawn and anxious. The accessory muscles of respiration are powerfully contracted; after several ineffectual gasps, he succeeds in taking a labored inspiration, and after seconds or minutes breathing gradually becomes normal. For minutes or hours he feels more or less muscular weakness. It seems not improbable that temporary paralysis of the diaphragm, induced in a reflex manner by the mechanical irritation of the sympathetic nerves of the abdomen, may account for the condition.

Rupture of the Abdominal Muscles.—Rupture of the abdominal muscles occurs as the result of contusions of the abdominal wall, very rarely as the result of muscular effort, in healthy persons. Among alcoholics and during acute infectious diseases—notably typhoid fever—rupture of the rectus abdominis is not a very infrequent accident. The rectus abdominis is ruptured in most instances below the umbilicus. The number of cases in which the oblique or transverse muscles have been ruptured is very small. The diagnosis is to be made from the history of a blow, a sudden muscular strain, or a violent hyperextension of the trunk. The patient will have felt a sharp pain at the point of rupture, and often a sense of something giving way. There will be localized pain and tenderness. If the patient is not too fat, palpation will discover a pit or sense of diminished resistance at the point of rupture; sometimes a sense of fullness above or below. In ordinary cases the rupture heals by the production of a scar in the substance of the muscle. If the rupture has occurred during typhoid, or some other infectious disease, suppuration may occur by hematogenous infection. In some cases the anterior layer of the rectus sheath may be ruptured by blunt violence. The belly of the muscle may protrude through the rent and be palpable as a tender tumor. In all cases of contusion of the abdomen, even if not very severe, there is risk of injury to the viscera—notably to the intestine. The nature of the accident should be inquired into carefully. Those injuries in which the abdomen is compressed against a solid support—as the ground, a wall, a railway-car buffer, etc.—are always to be regarded as serious. A long continuance or increase in the symptoms of shock, or a return of such symptoms after hours or days, points to intra-abdominal hemorrhage or rupture of the gut; general abdominal pain and muscular rigidity, extending beyond the injured area, to rupture of the gut and peritonitis; the general symptoms of hemorrhage, abdominal pain, and dullness on percussion in the flanks to free blood in the belly. It is to be borne in mind that contused gut may slough and permit the escape of intestinal contents after many days; hence, contusions of the belly are always to be regarded as possibly dangerous injuries.

Wounds of the Abdominal Wall.—Nonpenetrating, incised wounds of the abdominal wall are not dangerous injuries, if clean. The only important vessels likely to be injured are the deep epigastric artery in front and the lumbar arteries behind. The deep epigastric is given off from the external iliac opposite the center of Poupart's ligament, and runs upward and inward behind the rectus muscle, which it supplies, to anastomose in the epigastrium with the internal mammary. If cut, both ends of the divided vessel should be tied. Wounds of the lumbar arteries are rare. The superficial epigastric, if cut between Poupart's ligament and the umbilicus, scarcely gives rise to serious bleeding. In many instances the nature and extent of the injury will be readily evident on inspection. Wounds of the sheath of the rectus, of the external oblique aponeurosis, of the muscular bellies, for example. Such wounds are quite common among negroes in the city of New York. They

are usually razor cuts, and run transversely or obliquely across the belly, and often cut the intestine. Among Italians, narrow stab wounds are commonly observed; they are made with pen-knives, slender daggers, or sharpened files. Incised and stab wounds made with carving knives, butchers' knives, and sailors' sheath knives are quite commonly seen in the hospitals of New York City. In a large proportion of the cases the peritoneum is opened and one or other of the abdominal viscera injured, most commonly the small intestine, sometimes the stomach and colon, occasionally the liver, rarely the kidney. It is stated that among miners in Mexico assaults with daggers are not infrequent; the victim is usually stabbed from behind, and the ascending or descending colon is frequently wounded. When the nature of the weapon or the symptoms make it probable that the wound opens the peritoneum, it should be explored by direct vision, and with every possible aseptic precaution, best under a general anesthetic, the original wound being enlarged for the purpose, if necessary. If a hole of some size exists in the peritoneum, omentum, or, less often, intestine may be found prolapsed in the external wound. (See Penetrating Wounds of the Abdomen.)

Contused and Lacerated Wounds of the Abdominal Wall.—Contused and lacerated wounds of the abdominal wall are produced by blunt violence, by a blow of a horse's hoof, by machinery accidents, by explosions, by the falling of iron beams, etc. They are often attended by extensive stripping of the tissues and by loss of substance, so that the muscles may be laid bare over a considerable area. When produced by purely blunt violence they rarely, if ever, open the peritoneum. No difficulties exist in the diagnosis, as far as the abdominal wall is concerned. Foreign bodies should be sought for.

Gunshot Wounds of the Abdominal Wall.—Gunshot wounds of the abdominal wall usually penetrate the peritoneum; such will be spoken of under injuries of the abdominal contents. Occasionally a tangential shot may fail to do so, or a spent bullet may cause a more or less superficial contused wound; only rarely a bullet, traveling at low velocity, may be deflected by fascial planes and follow the contour of the abdominal wall for a variable distance, to lodge or emerge. In cases of doubt, palpation or the X-rays will locate the missile, if present. The signs and symptoms of injury of the abdominal contents will be absent. It should not be forgotten that a shell fragment, or even a bullet, may cause rupture of the gut without perforating the abdominal wall.

Foreign Bodies in the Abdominal Wall.—Foreign bodies in the abdominal wall may be introduced from without through a wound; such are splinters of wood, portions of clothing, needles, a portion of a knife blade, etc.; or they may have been swallowed, and have ulcerated through the intestine, to appear usually in the region of the umbilicus. In the first class the foreign body, if bearing pyogenic germs, causes the wound to suppurate until it is extracted. In the second the intestine may become adherent to the abdominal wall, and an abscess may form from which the body is extracted, leaving a fecal fistula

behind, which may close spontaneously or not; or the abscess, when opened, may have ceased to communicate with the gut, or the foreign body—a needle, for example—may merely cause a point of local pain and tenderness in the abdominal wall without inflammatory signs.

DISEASES OF THE ABDOMINAL WALL

Inflammations.—Furuncles, superficial abscesses, occasionally carbuncles and diffuse phlegmonous processes, occur in the skin and subcutaneous tissues of the abdominal wall as in other situations. They present no special diagnostic features. (See these topics in chapters on General Surgery.) Scalds and burns of the abdominal wall, from steam, flame, acids, and alkalies, are not rare. I saw a man die in three days from erysipelas of the abdominal wall following a scald of the abdominal wall and scrotum.

Deep-seated Inflammations.—The deep-seated inflammations are of more interest. Suppuration in the deeper structures of the abdominal wall may be due to primary infections from open wounds, to hematogenous infections in the course of infectious diseases, to metastatic infections in the course of pyemia. In many cases the infection is due to the extension of suppurative processes from near or distant organs or structures, or to traumatisms involving the bladder or the intestine. Certain of these inflammations occur near the middle line of the belly in front, between the umbilicus and the pubes. Among the primary infections may be mentioned suppuration in the rectus sheath, usually in front of the muscular bellies and below the umbilicus. Such suppuration may follow rupture of the muscle in the course of typhoid fever. In addition to the general signs of sepsis, more or less marked, there will be local pain and tenderness and the formation of a tumor which becomes more prominent and less movable when the recti are put in action—as in rising to a sitting posture. A subcutaneous abscess may usually be moved a little irrespective of the action of the recti. The tumor may be unilateral or bilateral, and will correspond in situation and contour with the rectus sheath.

Suppuration behind the muscles may occur in several situations: (1) Around the umbilicus; (2) in the loose connective tissues behind the recti; (3) in the prevesical space (cavum Retzii); (4) in the properitoneal connective tissues. It is to be borne in mind, that while anatomically these several spaces can be recognized as distinct and separate, and clinically inflammations are in many cases limited by these anatomical boundaries, yet in other instances infection may involve two or more of the spaces at the same time. The most important of these spaces is the space of Retzius, or prevesical space. Suppuration may occur here from a variety of causes, among them trauma, either subcutaneous or open, to the lower part of the belly, with the formation of a hematoma in the prevesical space, which becomes infected and forms an abscess. I have seen abscesses in this region follow fractures of the pelvis, with or without evident rupture of the membranous urethra or bladder. When

extensive extravasation of urine takes place, the symptoms of general intoxication of a virulent character are added to the local signs. Sometimes we are unable to trace the cause of the infection, although some local cause probably exists in nearly all cases. Among the causes of secondary suppuration in the

FIG. 253.—LARGE ABSCESS OF THE ABDOMINAL WALL ORIGINATING IN THE SHEATH OF THE RECTUS MUSCLE. (New York Hospital Collection, service of Dr. F. W. Murray.)

prevesical space may be mentioned suppurative processes of the prostate and seminal vesicles; cystitis and pericystitis, whether of gonorrheal or other origin; ulceration of the bladder wall; osteomyelitis of the pelvic bones; suppurative inflammation of the retroperitoneal glands following chancroidal or ordinary pyogenic infection; ulcerative processes of the sigmoid flexure; possibly, also, of the vermiform appendix.

A so-called hygroma of the prevesical space was described by Guyon, who has seen several cases.

Signs and Symptoms of Acute Suppuration in the Prevesical Space.—The signs and symptoms of acute suppuration in the prevesical space are fairly characteristic; the ordinary constitutional symptoms of septic infection are

present; in addition there may be symptoms of peritoneal irritation, nausea, and vomiting. The pressure upon the bladder causes painful and often difficult urination or retention of urine. There is pain in the lower part of the belly, of an intense character, so that the patient may lie with his knees drawn up, as in some cases of peritonitis. Upon inspection and palpation a rounded, tender tumor can be seen and felt above the pubes, resembling in situation and contour a distended bladder. *Evacuation of the bladder with a catheter does not cause the tumor to disappear.* The tumor gives a flat note upon light percussion. The introduction of an aspirating needle withdraws pus.

Tuberculosis of the Space of Retzius.—Tuberculosis of the space of Retzius has been observed secondary to tuberculosis of the recti muscles. Acute symptoms are wanting.

Suppuration Behind the Recti.—Suppuration behind the recti in the submuscular or in the properitoneal tissues is occasionally observed as a primary condition without evident cause. The tumor has a higher situation than those just described; it is broader above toward the umbilicus, and tapers off toward the pubes. Symptoms of pressure upon the bladder are absent; urination is not affected. In a case I operated on some years ago the patient was an elderly man, who had previously enjoyed good health. He entered the hospital suffering from pain in the lower part of the abdomen and moderate sepsis. A rounded, painful, tender mass could be felt in the abdomen, extending from the umbilicus to the pubes, flat on percussion. Incision evacuated a pint or more of pus lying behind the recti muscles, above the bladder and in front of the peritoneum. No cause could be found for the abscess, which healed in due course.

Deep-seated Suppuration in the Flanks.—Deep-seated suppurative processes in the lateral regions of the abdomen may be due to extension from a great variety of lesions. Those proceeding from the kidney or from the perirenal connective tissues present in front of the outer border of the quadratus lumborum muscle. In a good many cases the kidney itself is not involved. The deep origin of the process renders an early diagnosis difficult without a history of injury or the signs of a suppurative lesion of the kidney (pyuria, etc.). There will be general symptoms of sepsis, pain, and deep tenderness in the loin below the ribs, and a sense of resistance on bimanual palpation of the loin. When the abscess becomes subcutaneous, a tender, fluctuating tumor will be formed. An aspirating needle may be cautiously used to establish the diagnosis. Sometimes these abscesses develop quite slowly; several weeks may elapse after the commencement of the symptoms before the local signs permit a positive diagnosis. This is notably true in stout persons, where deep-seated palpation of the abdomen is difficult. I recall a case of this kind in a physician who had tenderness and pain beneath his short ribs, and moderate symptoms of sepsis, for several weeks before pus could be obtained through a long needle. No cause could be found for this abscess. (See also Perineal Inflammations.)

Suppurative processes, acute or chronic, arising from the vertebræ and

ribs may present in the same region; concomitant signs and symptoms must be sought for. In the iliac region inflammatory tumors in great variety may become superficial. Among them may be mentioned abscesses from the appendix, from the uterine adnexa, and from the bladder; inflamed aneurisms of the iliac vessels; abscesses from the kidney and ureter, from the pelvic bones, and from caries of the spinal vertebræ; perforations of tuberculous or malignant growths of the ileum, cecum, and ascending colon on the right side, of the sigmoid flexure on the left; actinomycosis of the cecum, etc. The diagnosis of some of these conditions is not difficult from the history and physical signs. If the suppurative process is acute, the presence of pus can usually be determined by simple methods of examination; to determine its origin may be quite difficult. In chronic cases the diagnosis may be very puzzling; the history, the functional disturbances of special organs, if present, may aid. Often the diagnosis will only be made at the time of operation.

Actinomycosis of the Abdominal Wall.—Actinomycosis of the abdominal wall is always secondary to actinomycosis of the gut, usually of the cecum. The infection becomes superficial in the right iliac fossa in most cases, less commonly in the umbilical region. If an intestinal tumor and intestinal symptoms have preceded the invasion of the abdominal wall, the diagnosis may be simple; if not, it will be difficult. A firm, indurated area, usually of small size, will be palpable in the abdominal wall, not sharply circumscribed, covered by normal skin. The progress of the disease is usually slow and chronic, unless a considerable hole forms in the intestine, when a phlegmonous inflammation, with septic symptoms, may result from the escape of intestinal contents. Ordinarily the skin is slowly involved, becomes reddened, and finally perforated with the discharge of pus usually having a fecal odor and containing actinomycosis granules. In some cases the granules will only be recognized in the granulation tissue lining the sinuses.

Tumors of the Abdominal Wall.—Fibroma.—The abdominal wall may be the seat of fibroma molluscum. Soft fibroma, either as an isolated growth or in conjunction with disseminated tumors of like character. (See Fibroma.)

Dermoid Tumors of the Abdominal Wall.—Deep-seated fibromata having certain interesting characters may arise from the tendinous and fascial layers of the abdominal wall. Histologically they may be pure fibromata, or occasionally combined with myxoma, sometimes with the formation of cystic cavities. These tumors occur for the most part in women between twenty-five and thirty years of age, and may appear after labor. They are rare in men. They have followed trauma to the abdomen in certain cases. They appear in the sheath of the recti muscles; less often in the oblique or transverse muscles of the abdomen. They may grow outwardly toward the surface or remain behind the muscular wall of the belly. They are tumors of moderately rapid growth, and may reach a large size in two or three years. They are hard, firm tumors, of smooth or coarsely knobby surface, firmly attached to the surrounding tissues, sometimes painful, but not tender. After the tumor

attains some size the subcutaneous veins may be dilated. Mechanical irritation may lead to superficial ulceration, infection, and sepsis. When the tumor is superficial the differential diagnosis lies between fibroma and sarcoma. The fibromata usually merely displace the surrounding tissues, and do not infiltrate them. When the fibroma is deeply seated it may be mistaken for an intra-abdominal growth, or for an intra-abdominal malignant growth which has invaded the abdominal wall. There will be flatness on percussion over the tumor, absence of symptoms pointing to a serious lesion of the intestine or other organ. Bimanual examination will exclude fibroma of the uterus.

Fig. 254.—Sarcoma of the Abdominal Wall. The tumor was removed and found to invade the entire thickness of the abdominal wall. The patient was an old and feeble woman. Death from shock. (Service of Dr. Charles McBurney, Bellevue Hospital.)

Fig. 255.—Mixed-celled Sarcoma of the Abdominal Wall. (Author's collection.) See text.

The tumor will not move with respiration except to take part in the movements of the abdominal wall. The cachexia and ascites common in malignant new growths of the abdomen will be wanting. From sarcoma of the abdominal wall the diagnosis is impossible without the aid of the microscope.

Sarcoma.—Sarcoma of the abdominal wall is rather uncommon. The tumor may originate in a fibroma or in a pigmented nevus or mole; in the latter case melano-sarcoma is usually the type found, or sarcomata may originate in or beneath the skin *de novo*. Here,

as elsewhere, the disease varies in malignancy, and possesses the usual history and characters. The muscles of the abdominal wall are often invaded early, but the peritoneum is usually spared until late in the disease. Ulceration, bleeding, sloughing, and metastasis regularly take place. The prognosis is generally unfavorable. The illustration shows a mixed-celled sarcoma of the abdominal wall of a woman aged thirty-two. The entire thickness of the abdominal wall was invaded, except the peritoneum. The tumor had been growing three years. After I removed it the woman remained well for two years. Local recurrence then took place, from which she died.

Lipoma.—Lipoma may occur in any of the layers of the abdominal wall, chiefly in the subcutaneous and in the properitoneal fatty tissues. The subcutaneous lipomata occur rather at the sides than in the middle of the abdomen. They are slow-growing, usually sessile, rarely pedunculated tumors, and may attain a large size in the course of years. Their characters are those of lipoma elsewhere. (See Tumors.) Diffuse lipoma may also occur. The subserous lipomata are quite peculiar tumors. They occur in the middle line of the belly, above the umbilicus, and are usually quite small. They perforate the linea alba, and appear as small masses of fat in the middle line beneath the skin. Often they drag a small process of peritoneum after them, creating thus a small peritoneal sac. They are sometimes wholly or partly reducible through the hole in the fascia. There are sometimes digestive disturbances, nausea and vomiting and abdominal pain, accompanying these tumors. The differential diagnosis between them and a small hernia containing adherent omentum, or a small, empty hernial sac covered by a layer of subserous fat, is often impossible except by operation. When the patient has a thick panniculus adiposus, the difficulty is greatest. Upon pushing these fatty tumors back through the hole in the fascia, the pain and digestive troubles often disappear at once.

Epithelial Growths of the Abdominal Wall.—Epithelial tumors of the abdominal wall are infrequent. Papillomata and sebaceous cysts may occur. (See Tumors.) Epithelioma may develop in scars or from chronic irritation of the skin, possibly from an X-ray burn of considerable depth. Secondary carcinomata of the inguinal glands are common following carcinoma of the uterus, rectum, penis, scrotum, and lower extremities. It has rarely happened that a carcinoma of the stomach or intestine has become adherent to, and finally perforated, the abdominal wall. The recognition of all these conditions is not difficult, having in mind the history of or actual presence of the primary growth.

Echinococcus of the Abdominal Wall.—Echinococcus of the abdominal wall is one of the rarest localizations of this disease, only a very few such cases having been observed. The cysts may be located in the lumbar or umbilical regions or elsewhere. A differential diagnosis from echinococcus of an intra-abdominal origin may be difficult, since if the cyst originate behind the muscular wall of the belly, it will grow into the abdominal cavity and form adhe-

sions to the viscera. The disease is slow and insidious in its progress. The patients suffer from abdominal pain, disturbances of digestion and nutrition. Pressure symptoms upon the diaphragm causing dyspnea are absent, thus serving to exclude echinococcus of the liver. If pus infection takes place, the symptoms of sepsis are added. The abdominal wall may be perforated with evacuation of the sac. When the signs are such that an intra-abdominal origin cannot be excluded, it will be unwise to use an aspirating needle for diagnostic puncture, since the peritoneal cavity might thus be infected by the escape of the contents of the cyst. (See Echinococcus.)

DISEASES OF THE UMBILICUS

Congenital Anomalies of the Umbilicus.—Imperfect closure or failure to close of the omphalomesenteric duct—normally closed at the end of the eighth week of fetal life—may cause congenital anomalies of the umbilicus. A number of different conditions may exist.

1. The communication with the small gut may remain patent from the intestine through the umbilicus and into the cord (omphalomesenteric fistula).

2. The duct may be closed up to the umbilicus, but patent outside the abdomen (umbilical omphalomesenteric diverticulum).

3. The duct may be closed from the intestine, and also at the umbilicus, but patent between these points (omphalomesenteric cyst).

4. The connection between the duct and the umbilicus is not present, but the communication with the intestine remains open, forming an intestinal diverticulum of variable size and length, situated from a foot to twenty inches from the ileo-cecal valve (Meckel's diverticulum). The most common anomaly of the four, found in about one individual among fifty. (See Meckel's Diverticulum.)

1. Omphalomesenteric Fistula.—When the duct is patent throughout, separation of the cord after birth will leave behind a fistulous orifice lined by mucous membrane, which discharges mucus or mucus and intestinal contents. The former variety is to be differentiated from the much rarer congenital fistulæ of the stomach by the fact that the latter furnish an acid secretion which may digest the surrounding skin. In another rare form the intra-abdominal pressure causes a protrusion of the mucous membrane of the duct; this prolapse may increase, dragging the intestine after it until the latter leaves the abdomen and lies as an everted loop upon the belly. There will then be found two orifices, both leading into the intestine. A congenital umbilical anus exists. If the umbilical ring is small, such children may die of intestinal obstruction. A careless ligation of the cord in the presence of a congenital umbilical hernia containing intestine may wound or divide the gut. Careful palpation of the cord, should it seem thicker than normal, should detect the presence of intestine from the characteristic gurgling and reducibility.

2. Omphalomesenteric Diverticulum.—In this form, after the separation of the cord, a small, red, moist tumor remains behind, covered by mucous membrane; this may reach the size of a raspberry, which it somewhat resembles in appearance. The mucous membrane passes off the surface of the tumor into the normal skin of the abdomen. No fistulous opening through the umbilicus into the intestine exists, thus differentiating the condition from omphalomesenteric fistula in which a probe can be passed through the fistulous tract into the gut.

3. The omphalomesenteric cysts are so rare that their description is here omitted.

4. See Meckel's diverticulum.

Congenital Anomalies of the Urachus.—The fetal tube connecting the urinary bladder with the allantois may remain patent at birth: (1) From the bladder to the umbilical cord. (Congenital urachus fistula.) (2) The urachus may communicate with the bladder and remain open a variable distance in the abdomen, but the opening does not extend to the umbilicus. An umbilical urinary fistula may develop during infancy or later in life. (3) The urachus is closed off from the bladder and at the umbilicus, but remains patent between these points. A urachus cyst may develop in later years between the bladder and the abdominal wall—a rare condition. The etiological relation, however, between such cysts and the urachus is denied by some observers.

1. In the first variety, after the cord separates, a fistulous tract is present, lined by mucous membrane from which urine escapes, continuously or intermittently, in larger or smaller quantity. Commonly a prolapse of the wall of the urachus occurs, forming a considerable projection from the navel, of cylindrical shape; the urachus opens at its tip. If the umbilical ring is large the bladder may prolapse, and much or all of the urine may escape through the umbilicus. Before closing the opening the surgeon should look for obstruction to the outflow of urine through the normal channels, phimosis, or a narrow meatus urinarius. If infection of the urachus takes place the discharge may be purulent and ammoniacal.

2. The second variety rarely if ever gives rise to symptoms unless infection occurs, usually through the bladder. The trouble may arise during childhood or adult life. An inflammatory tumor will then be formed behind the pubes. There will usually be purulent urine and symptoms of cystitis. The tumor may rupture externally, or an incision will enter a cavity above and in front of the bladder containing a mixture of urine and pus. Occasionally a calculus has been removed from such a cavity.

3. Although the above conditions are rare, the third variety, "urachus cysts," is still more rare. They present as noninflammatory tumors in the suprapubic region, giving the physical signs of a cyst—dullness on percussion and elasticity on palpation. The diagnosis can be made from the character of the epithelium lining the cyst wall.

Inflammatory Processes of the Umbilicus in Infants and Adults.—After the separation of the cord the stump may become the seat of a small granuloma. The characteristic appearances of granulation tissue covered by a purulent discharge, and the generally pedunculated shape of the growth, together with absence of the signs of fistula, render the diagnosis easy.

Infection of the Umbilicus.—Infection of the umbilicus among infants and among children may occur in a variety of forms. Diphtheria, tetanus, pyogenic cellulitis, noma, phlegmonous inflammation of the abdominal wall, septic phlebitis, leading to thrombosis and secondary abscesses in the liver, or pyemia, peritonitis, are all observed, usually as the result of uncleanliness and depressed states of vitality. These conditions give rise to signs and symptoms, fully discussed under appropriate headings. Among adults inflammations of the umbilicus occur for the most part among those who do not bathe, and who are obese or have a deep umbilicus. Intertrigo and eczema are observed among fat women in this region. In rare cases where the umbilicus is very deep and the external skin orifice is narrow, neglect of cleanliness may be followed by retention and decomposition of the sebaceous and other secretions of the skin. The umbilicus becomes swollen, red, and tender, a stinking, smeary discharge escapes from the umbilical ring, and a considerable quantity of foul-smelling sebaceous matter may be removed from the cavity with a scoop.

Perforations of the Umbilicus in Adults.—A great variety of inflammatory conditions of the abdomen may perforate the umbilicus, and discharge pus or other material, often leaving a fistula behind. Among these conditions may be mentioned traumatic and inflammatory ruptures of the bladder; a urinary fistula is then formed. Cholecystitis may form an abscess pointing at the navel with the discharge of pus, gall-stones, and bile. Perforations of the intestine from many causes may discharge at this point. Such may be gangrenous perforation of a strangulated umbilical hernia, a strangulated or perforated Meckel's diverticulum, an abscess arising from the vermiform appendix, a typhoid perforation, and perforation from a foreign body in the stomach or intestine. Through such perforations intestinal or stomach contents will be discharged, together with pus, a foreign body, occasionally round- or tape-worms. I recently operated upon a woman who had had an intestinal fistula at the umbilicus for eight years. The fistula followed some illness the nature of which was not clear. There were two holes in the small gut and one in the sigmoid. The holes were closed by suture. The patient was cured.

A malignant growth of the gut, an echinococcus cyst, a tuberculous peritonitis, an ovarian cyst, or even an ascites from any cause, may rupture at this point. Usually the diagnosis will be plain from the history of the case and the character of the discharge, exploration of the fistula with a sound or probe, and other concomitant signs and symptoms which point to some definite causation. In certain instances the source of the fistula can be determined, more or less accurately, by injecting colored fluids into the fistulous tract or into the bladder, the rectum, or causing the patient to swallow such a fluid (methy-

lene blue solution, for example). The subsequent appearance of the fluid in the rectum, stomach, bladder, or at the orifice of the fistula, as the case may be, will sometimes afford valuable information.

Tumors of the Umbilicus.—Soft papillomata or papillary fibromata may occur in the umbilicus from chronic irritation. The tumor has the characteristic pink color and cauliflower appearance, and an offensive thin discharge may occur from the macerated surface. Such papillomata may ulcerate and resemble epithelial cancer. The microscope must be used for diagnosis in these cases. Sarcoma of the umbilicus has been observed chiefly in women in the form of a rather slow-growing and not very malignant fibro-sarcoma. The tumor is rather hard, sessile, and may reach a considerable size before the patient suffers enough inconvenience to make her seek advice. The tumor is covered by normal or bluish skin, there may be dilated veins upon its surface. Ulceration may occur from trauma. Fibroma, fibro-lipoma, myxoma, and angioma of the navel have been observed. Atheromatous and dermoid cysts also occur.

Carcinoma.—Both the slow and rapidly growing forms of epithelioma are observed among elderly people, usually as the result of chronic irritation from dirt, or upon a simple papilloma as a basis. The characteristic hard, ulcerated surface with prominent, firm edges and other characters, as described under Tumors, render the diagnosis simple. Carcinoma having cells resembling intestinal glandular epithelium, scirrhus, and other forms of cancer are occasionally seen growing from the umbilicus. The characteristic history and signs of cancer are present. Carcinoma of the navel may also occur secondary to cancer of the stomach, intestine, or uterus, either by direct extension or metastasis. The microscopical characters of the tumor will indicate the character of the primary growth.

CHAPTER XXIV

THE PERITONEUM

General Considerations.—The peritoneum lines the abdominal cavity, forming by far the largest serous sac in the body, its surface being about equal in area to that of the general integument. The membrane is reduplicated over the surface of the abdominal and pelvic viscera in such a manner that certain organs receive almost a complete covering of peritoneum (jejunum, ileum, transverse colon, stomach); in others, the covering is only partial (duodenum, cecum, bladder); in still others, the organ simply lies in contact with this membrane, which passes smoothly across its surface (kidney). The anatomical details are mentioned, when necessary, under the injuries and diseases of the separate organs. The opposed peritoneal surfaces lie everywhere in contact; a capillary space merely exists between them. The surface is covered by flat endothelium. On the abdominal wall, peritoneum is but loosely attached to the surrounding tissues; the same is true of the bladder, much of the intestine, and stomach. Its reflection over certain solid organs—liver and spleen—is firmly adherent to the underlying connective-tissue capsule of these viscera. In the male the peritoneum is a closed sac (stomata having been described by some observers as existing in the peritoneum covering the diaphragm). In the female the open ends of the Fallopian tubes afford communication with the interior of the uterus, and infectious processes readily spread from the uterus and tubes to the peritoneum. Various physiological recesses, folds, bands, and orifices exist in the peritoneum, some of which are important in relation to the diagnosis of hernia and intestinal obstruction, as well as to the spread and accumulation of inflammatory exudates. They will be mentioned under appropriate headings. The intimate relation of the peritoneum to the abdominal organs is very important surgically. Injuries of the peritoneum usually involve the viscera, and diseases of the viscera quite commonly extend to the peritoneum; indeed, diseases beginning in the peritoneum itself are exceedingly rare as compared with those beginning in adjacent structures and extending to the peritoneum. When disease of a septic character penetrates one of the abdominal viscera and invades the peritoneum, the clinical picture is quite commonly changed with great suddenness. The symptoms caused by inflammation of the peritoneum entirely overshadow in gravity and importance those caused by the original lesion of the viscus.

Sources of Infection of the Peritoneum.—Infection of the peritoneum occurs through wounds and inflammations of the abdominal wall. Much more commonly, through wounds, inflammations, and perforative lesions of the alimentary tract; of these, the most frequent source is the vermiform appendix. Among other frequent sources are peptic ulcers of the stomach and duodenum; typhoid ulcers of the ileum; tuberculous and cancerous ulcerations of the cecum; tuberculous, syphilitic, and cancerous ulcerations of the sigmoid flexure and transverse colon. A foreign body in the intestine may cause ulceration and perforation. Distended bowel above the seat of a stricture may be the seat of ulceration and perforation, due to pressure. Infection also occurs through strangulated and partly or wholly gangrenous coils of intestine, in cases of strangulated hernia, volvulus, strangulation by bands, intussusception; through suppurative or necrotic lesions of the glandular organs of the belly—liver, bile passages, pancreas, spleen, kidney, and ureter; through the tissues of the uterus in septic infections of that organ by way of the lymph canals; through the open mouths of the Fallopian tubes, and through infections of the ovary; through infectious lesions of the bladder, prostate, seminal vesicles, and spermatic cord; through lymph vessels and lymph glands of any of the pelvic or abdominal organs; through infected thrombi or emboli of arteries and veins of the abdomen; through inflammatory processes of the pleura, vertebræ, or pelvic bones. Cases of hematogenous infection of the peritoneum with pyogenic microbes—i. e., cases of so-called idiopathic peritonitis, with no discoverable lesion which might account for the infection, are so rare that their existence is doubtful.

Bacteria Causing Peritonitis.—Streptococcus pyogenes is the most frequent as well as the most dangerous invader of the peritoneum; staphylococcus is less common. The saprophytes of the intestine (Bacillus coli communis) are regularly present in perforative lesions of the alimentary tract. The growth of this form is so vigorous that other bacteria may disappear, so that, when at the time of operation a culture is taken from the exudate, bacillus coli may be the only germ found, the original infection having been caused perhaps by streptococcus or some other organism. Among other bacteria found in cases of peritonitis are the pneumococcus, Bacillus typhosus, and the gonococcus.

Infection with tubercle bacilli may occur as a part of a general tuberculosis or as a localized process. (See Tuberculous Peritonitis.) Apparently hematogenous infection of the peritoneum with pneumococcus occasionally occurs as a complication of pneumonia. Peritonitis is occasionally observed in acute articular rheumatism, probably a septic disease.

Behavior of the Peritoneum when Exposed to Infection and Trauma.—The surface of the peritoneum is very large, its absorbing power is very great, and fluids are taken up from its surface with extraordinary rapidity. The reparative power of the peritoneum exceeds that of any other structure, and repair is very rapid. These facts have a bearing upon the course of peritoneal

injuries and infections. When exposed to septic irritation the peritoneum reacts speedily, throwing out an abundant exudate of serum, fibrin, or pus, or a combination of these ingredients. The fibrous exudate is often abundant and serves to cause agglutination between opposed peritoneal surfaces, thus limiting the spread of infection more or less completely. It has been demonstrated that the normal peritoneum is capable of absorbing, and thus disposing of considerable quantities of bacteria and their toxins without any inflammatory reaction. If the peritoneum is wounded, bruised, or unduly irritated, mechanically or chemically, as by rough handling or the action of chemical antiseptics, or if foreign bodies are present, such as masses of blood, fragments of contused or dead tissue, masses of fibrin, a piece of gauze, etc., thus constituting a dead space, in which bacteria may flourish, this power of absorbing and destroying the bacteria is lost or decidedly impaired. Infection and inflammation of the peritoneum follow. The character and course of the inflammation varies widely in different cases, being modified by factors, some of which we shall presently discuss. It will be convenient for purposes of classification to divide peritonitis into several generally recognized types:

I. Peritonitis caused by pyogenic and saprophytic germs.

1. Peritoneal sepsis; diffuse septic peritonitis.

2. Progressive purulent peritonitis, with putrid decomposition.

3. Progressive fibrino-purulent peritonitis.

4. Localized peritonitis.

5. Chronic peritonitis: (*a*) empyema of the peritoneum; (*b*) chronic adhesive peritonitis.

II. Aseptic peritonitis.

III. Tuberculous peritonitis.

The severer forms of peritonitis are distinguished by their *progressive character* and by the pronounced septic symptoms accompanying them. The process tends to advance and to involve a large extent of peritoneum—i. e., to become diffuse or general, and rapidly to destroy life by septic absorption and by producing intestinal paralysis. The several types can be differentiated clinically from the *localized* form in which a small or moderate area of the peritoneum only is inflamed, the spread of the process being prevented by firm adhesions. It is to be borne in mind that a process at first distinctly localized may suddenly or gradually become diffuse. The fibrinous barriers may be invaded by pyogenic germs and liquefied, permitting a sudden or gradual spread of septic material into the noninfected portion of peritoneum. It is not always possible to distinguish the more severe types one from the other. Indeed, one may find, upon opening the abdomen, that several processes coexist. In one part of the belly a localized abscess filled with stinking pus, and shut off by adhesions; in another, a diffuse and spreading fibrino-purulent exudate; in a third, a cloudy serous effusion containing red and white blood cells; in a fourth, fibrin alone in thick flakes and masses; in a fifth, slightly cloudy serum, which

may be sterile. The inflamed coils of gut have lost their luster; they are deep red, swollen, and edematous, coated here and there with flakes of fibrin; usually distended, and temporarily or permanently paralyzed.

The character and course of the inflammation in the given case depends upon a number of conditions. *Sudden* perforations or ruptures of the alimentary canal, or *sudden* pouring out of septic material, from a gangrenous or purulent focus, so that a large dose of virulent bacteria and their toxins is thrown at once into the peritoneal space, is usually followed by an intense and rapidly progressive peritonitis, or by an acute septic intoxication, resulting in collapse and death, before much inflammatory reaction has occurred. In the latter case the amount of exudate is small, of thin sero-purulent or bloody character, sometimes brown in color, and putrid. No adhesions are formed, and the septic material is freely and rapidly diffused throughout the abdominal cavity. The peritoneum is dull but not notably swollen nor reddened. Scattered flakes of fibrin may be present. The patient is suddenly seized with an excruciating pain in the abdomen; sometimes general; sometimes referred to the umbilicus; sometimes to the seat of the perforation. The belly is flat or retracted (the scaphoid abdomen); the muscles of the abdominal wall are of board-like hardness; general abdominal tenderness is present. The temperature may be elevated, normal, or subnormal. The pulse is rapid, feeble, and compressible. The face is pinched. The extremities are cold. Repeated vomiting occurs. The patient passes into a condition of collapse, from which he does not rally, and dies within, perhaps, twenty-four hours or less, from the time of general invasion of the peritoneum. This type of the disease is commonly called "peritoneal sepsis." It is seen more often from the sudden rupture of a gangrenous appendix than from any other cause. The symptoms are due to septic absorption rather than to the inflammation of the peritoneum.

Recent experiments performed on rabbits in the pathological laboratory of the Cornell University Medical College are interesting in this connection: It was found that after the injection of pure cultures of virulent pyogenic microbes into the peritoneal cavity, blood cultures, taken five minutes after the injection had been made, showed the micro-organisms present in abundance in the circulating blood. *Thus it may well be that the condition we have been accustomed to regard as due to the absorption of bacterial toxins from the peritoneum is, in fact, a true septicemia.*

It has been found that during starvation the bacterial flora of the intestine are diminished in number. Moreover, the bacteria are less numerous in the upper than in the lower portion of the intestine. Perforation lesions, then, which occur when the intestine is nearly empty, and lesions which occur in the upper part of the small intestine and stomach, might be expected to produce a somewhat less violent peritonitis than when the intestine was full and the lesion low down. Experience shows that, in some cases, at least, this expectation is realized to this extent, that such perforations, when followed by extensive extravasation of the contents of the stomach or duodenum, are not attended

by profound septic symptoms nor by intense inflammation of the peritoneum for several hours.

Progressive Purulent Peritonitis with Putrid Decomposition of the Exudate.—Progressive purulent peritonitis with putrid decomposition of the exudate occurs when saprophytes are associated with the pyogenic cocci. Stinking gases may be formed in the exudate. The most intense and violent cases of peritonitis are caused, as a rule, by the streptococcus. The staphylococcus appears to be less virulent. Cases in which bacillus coli alone are found are, in my experience, attended by an abundant exudate, but not the most violent sepsis. The pneumococcus is also not very virulent. Cases of gonorrheal peritonitis usually remain localized in the lower part of the abdomen, but not always.

If perforation, or invasion of the peritoneum takes place, not suddenly but slowly, a plastic exudate of fibrin will be thrown out from the inflamed serous surface and adhesions formed, such that the spread of septic material in the belly is delayed or prevented. If such adhesions are inadequate the septic process spreads, slowly or rapidly, involving one area after another, so that communicating or apparently separate loculi—containing pus more or less completely walled off by fibrinous adhesions—are formed in different portions of the belly. Marked distention of the abdomen is often present in these cases. The amount of exudate is commonly large (progressive fibrino-purulent peritonitis). The spread of the infection tends to follow certain fairly definite routes—for example, infection beginning in the right iliac fossa tends to follow the outer surface of the ascending colon to the under surface of the liver. To follow the anterior surface of the ascending colon, and infect the under surface of the diaphragm and the upper surface of the liver. To travel downward to the true pelvis, thence to follow the rectum and sigmoid flexure upward in the direction of the spleen. The mesentery of the small intestine acts, to some extent, as a barrier to the direct crossing of the abdomen. Adhesions between the omentum and the abdominal wall may prevent the infection of the transverse colon and the stomach. In the same way the omentum may protect the small intestine when the infection has proceeded from the upper part of the belly.

In some of the cases of progressive purulent peritonitis the patient is not seen until the process has become fairly generalized. Such a condition may follow a blow or kick upon the abdominal wall—for example, with rupture of the intestine and the escape of intestinal contents, in quantity, into the peritoneal cavity. Suppose the patient to have survived for twenty-four hours. He will be found with a rigid and distended belly. The general symptoms are those of profound sepsis. Upon opening the abdomen, a gush of material resembling pea soup escapes under tension. The exudate consists of rather thin pus, mixed with flakes of fibrin and intestinal contents. A foul odor and gas may or may not be present. The intestinal coils are everywhere distended. The peritoneum is dull, coated with flakes of fibrin, in some places reddened,

edematous, and swollen. There are no separate loculi of pus; the exudate is found free in all accessible portions of the abdomen.

General and Local Symptoms of Diffuse Purulent Peritonitis, Considered in Detail.—All the forms of diffuse purulent peritonitis, from whatever cause, present a similar clinical picture. In some, and those the most rapidly fatal, the symptoms of septic intoxication predominate; the local lesions and symptoms do not have time to develop fully before death occurs (peritoneal sepsis). In others a slowly or rapidly spreading local lesion produces marked local signs and symptoms, and, in some cases, such a lesion is associated, for a time at least, with only moderate symptoms of septic intoxication (progressive fibrino-purulent peritonitis).

Some cases of diffuse peritonitis will have been preceded by a localized peritonitis from an acute suppurative appendicitis, for example. In others, disturbances of function of some special organ will be followed by perforation (ulcer of the stomach). In others, a general disease will exist (typhoid fever). In still others, the attack may suddenly appear in an individual apparently in good health (ulcer of the duodenum). Upon the advent of peritonitis definite symptoms appear at once. The constant symptoms are *abdominal pain and vomiting.* The distinctive signs are *tenderness and rigidity of the abdominal wall.* Frequently accompanying the onset of abdominal pain there is vomiting, occasionally chilly sensations, rarely a chill. The patient looks ill at once. He can scarcely stand upright, and lies down on his back as soon as may be. The expression of the face is disturbed, anxious, and, at first, often flushed; later, as the disease progresses, the features become pinched and drawn; as death approaches there is cyanosis. In order to diminish the tension of the abdominal muscles, the patient lies on his back with his knees and thighs flexed. He makes no movement which will disturb the abdomen, but, being in pain and restless, he may move his hands and arms frequently. He breathes as quietly as he may, the respirations are superficial and increased in frequency. Later, when the distended intestines push the diaphragm upward, breathing is still more distinctly thoracic, superficial, and rapid; sometimes gasping as the disease becomes far advanced. The voice is weak, and may be hoarse. In bad cases the tongue is coated, dry, and brown; sordes may be present on the lips and teeth.

Pulse.—In cases of peritoneal sepsis the pulse is that of shock, not necessarily very rapid, but weak, thready, and compressible. In cases of ordinary progressive peritonitis the pulse shows a continual increase in rapidity as well as a peculiar want of volume and tension. The pulse during the earlier stages of the disease may be 110 to 120 or more beats a minute. The sensation given to the finger is that the pulse wave is small. As death approaches the pulse becomes too rapid to count.

Temperature.—There is nothing characteristic about the temperature of peritonitis. In the worst cases, following the sudden flooding of the system with septic material, a subnormal temperature is the rule. If the patient sur-

vives for a day, an ordinary temperature curve of septicemia may be noted, up and down at irregular intervals. In cases of progressive peritonitis a moderate or considerable rise of temperature, such as is seen in any septic condition, is observed. *The important point to bear in mind is that the height of the temperature bears no necessary relation to the gravity of the disease, except that a subnormal temperature is a bad omen.* Often the temperature remains fairly low while the pulse grows more and more rapid.

Cerebration.—In some of the rapidly fatal cases the patient may be rather dull from the beginning; the benumbing effect of septic poisoning may cause him to feel but little pain. He will, however, look ill. Rigidity of the abdomen will be present. Ordinarily the mind remains clear until near the end, when delirium or stupor may occur. It sometimes happens that a patient who is doing very badly, and has suffered much from pain, dyspnea—due to distention—and painful vomiting, becomes benumbed as death approaches and feels relatively well.

Leucocytosis.—In peritoneal sepsis, such as follows rupture of a gangrenous appendix, no increase in the number of white cells in the blood may take place throughout the disease. In ordinary cases of advancing peritonitis a moderate or considerable leucocytosis is the rule. The differential count should always be made, since a relative increase in the polymorpho-nuclear forms is more significant than a mere general increase in white cells. Thus, while a leucocyte count of 10,000 to 12,000 has no marked weight in establishing the diagnosis, a relative increase of the polymorpho-nuclear cells to eighty or eighty-five per cent in such a count is strongly suggestive of a suppurative process. The value of the differential count in doubtful cases of beginning suppurative appendicitis has, in my experience, been considerable. When a localized peritonitis results in a walled-off abscess the leucocytes may diminish to normal, to increase again, temporarily, after the abscess is opened. (See, also, Appendicitis.)

Anorexia.—There is absolute loss of appetite in cases of diffuse peritonitis; the stomach refuses all food. Solids or fluids swallowed are either vomited at once or after a longer or shorter interval. Great thirst is commonly present.

The Urine.—The urine is diminished in quantity and high-colored. Indican is often present in considerable quantity, as well as a small amount of albumen. When the peritoneal covering of the bladder is inflamed there is either painful urination or retention of urine. If a considerable exudate compresses the bladder there will be a frequent desire to urinate.

Pain in Peritonitis.—Abdominal pain is one of the most constant symptoms of all the forms of acute peritonitis. In perforative lesions—traumatic or pathological—the escape of putrid, fecal, or purulent material into the belly is followed by pain of an intense and alarming character. The pain may be referred distinctly to the site of the perforation at once, or pain, at first diffused, may, later, be referred to some particular point after several hours. Thus a perforated ulcer of the stomach is usually accompanied by pain in the

epigastrium; ulcer of the descending portion of the duodenum by a pain referred to a point to the right of the median line, and at a level midway between the navel and the ensiform cartilage. A perforated typhoid ulcer by pain referred to the lower right quadrant of the belly or to the lower half of the belly. An inflammation of the appendix is accompanied by pain which may be referred to the right iliac fossa, at once, or, perhaps more commonly, is at first a general pain or is felt around the umbilicus or in the epigastrium, and only after some hours is referred to the appendical region. Peritonitis connected with the uterus, tubes, and ovaries is regularly referred to the lower part of the belly. If a single ovary or tube are at fault, the pain will often be distinctly unilateral. In peritonitis arising from the gall-bladder, the pain is usually referred to the lower border of the ribs at the edge of the rectus muscle on the right side. Sometimes to a point lower down, or to the whole right half of the belly. Only rarely is the pain of peritonitis referred to the side of the belly opposite to the lesion.

The location of the pain is thus a useful guide to the original lesion in many instances during the earlier hours of the disease. Later, when a large area is involved, pain is usually generalized, and is rarely of much diagnostic value as an indication of the seat of the original focus. There remain a few cases, both of diffuse and localized peritonitis, in which pain is not a striking symptom. In cases of peritoneal sepsis, without much inflammatory reaction on the part of the peritoneum and intense septic poisoning, pain is occasionally slight or almost absent. The pain of peritonitis is generally continuous, but is rendered worse by movement. Efforts to move the bowels by purgatives or enemata, changing the position in bed, the acts of urinating, vomiting, the hiccough, all increase the pain.

Tenderness.—A diagnostic sign of much value is localized and general abdominal tenderness. In well-developed cases of diffuse peritonitis this sign is so marked that no formal examination is necessary to elicit it. The patient protects his abdomen from movement and pressure by every possible means; even the weight of the bedclothes or an abdominal dressing is complained of, the weight of the hand anywhere on the abdomen causing increased pain. Under these conditions palpation of the abdomen gives little additional information. In the early stages, before perforation has occurred, or while the process is still localized, the signs of local tenderness, properly elicited, are of great diagnostic aid.

Palpation.—Palpation is carried out in two ways: The flattened palm is placed gently upon the abdomen, and the fingers quickly flexed at intervals, as the hand slides from one part of the belly to another. If inflamed peritoneum lies immediately beneath the hand, the patient will wince and complain of pain. During this manipulation the surgeon readily appreciates through his muscular sense the comparative degree of resistance offered to pressure by the muscles of different parts of the abdominal wall. A distinct rigidity over one quadrant of the belly combined with localized tenderness is strongly suggestive

of an underlying peritoneal irritation. As a differential sign between peritonitis in its early stages and functional disturbances of the intestine and other conditions, to be mentioned later, it is, I believe, the most valuable sign we know. If a subcutaneous injury with contusion of muscles exists, muscular rigidity will also be present; such rigidity is apt to be confined to the injured area. If such rigidity slowly or suddenly increases in extent it is probably due to the spread of peritoneal irritation. In well-developed diffuse peritonitis the abdominal wall is everywhere rigid.

Point Pressure.—Another method of eliciting tenderness is by what is commonly known as *point pressure*. The end of the forefinger is used to depress, more or less deeply, different parts of the abdominal wall. In this manner it is often possible to locate quite accurately a point of greatest tenderness; this will often correspond to the site of some particular organ, or portion of an organ, and in most cases indicates the origin or seat of the peritoneal infection. This method is especially valuable when the lesion is deeply placed, as in differentiating between an affection arising in the pyloric end of the stomach or duodenum and appendicitis; or the latter condition and a lesion of the tube or ovary. The value of the sign depends partly upon the fact that the seat of the referred pain does not always correspond to the situation of the lesion. For example, the pain of appendicitis is often referred to the epigastrium or umbilicus; periovaritis, etc., to the costal border; a kidney lesion to the course of the ureter, the bladder, the testes, even to the glans penis, etc. The sign will be referred to under Diseases of Special Organs.

Vomiting.—Vomiting is one of the most constant symptoms of acute peritonitis, both diffuse and localized. It is regularly present early in the disease, except under special conditions to be mentioned later. Preceding or accompanying the abdominal pain, the patient vomits the contents of his stomach. If the process advances or becomes diffuse the vomiting is repeated at frequent intervals. The vomited matters consist, at first, of the food previously swallowed, then of bile-stained, watery fluid, and mucus. The attacks of vomiting are at first violent and intensely painful. As the disease progresses, the character of the vomiting changes to a sort of spontaneous overflow from the stomach, accomplished without apparent muscular effort or retching; the vomited material suddenly pours out of the patient's mouth without warning. In bad cases of septic peritonitis, the vomit assumes a coffee-ground character, and is of gloomy significance. When the intestines become paralyzed the accumulation of fermenting material distends the paralyzed gut and flows mechanically into the stomach; the vomit may then have a dark-brown, green, or black color, and a fecal odor, as in intestinal obstruction. When coffee-ground vomit occurs after injuries to, or operations upon, the stomach, it may be due to bleeding from the stomach wound, and is not then necessarily of bad significance.

Absence of vomiting is noted in some cases of gangrenous appendicitis with perforation, and in other cases of peritoneal sepsis. If life is prolonged, so that

the peritoneum reacts to the poison and becomes inflamed, vomiting will then occur. In a few cases of peritonitis following wounds and perforations of the stomach there may be no vomiting.

Hiccough.—A distressing and painful symptom of acute diffuse peritonitis. Between the acts of vomiting, reflex spasm of the diaphragm causes, in many cases, frequent hiccough. I have observed it most often after wounds and perforations of the stomach. It may occur in any case of extensive peritonitis.

Tympanites, Meteorism—Distention and Paralysis of the Bowel.—In those speedily fatal cases of peritoneal sepsis followed by death in a few hours with but little true peritonitis, the belly is often flat or retracted; if the patient survives a day, the belly will become distended. In localized peritonitis—resulting in a walled-off abscess—distention may be slight. In all cases of progressive and diffuse purulent peritonitis distention of the bowels with gas, and marked enlargement of the abdomen, is regularly present, giving a tympanitic note on percussion. Upward pressure upon the liver and diaphragm causes diminution or loss of liver dullness and dyspnea. In bad cases the distended bowel is paralyzed, its contents undergo putrefactive changes with the production of much gas. At the beginning of the attack there may be one or more diarrheal movements. As the inflammation becomes diffuse, and the wall of the gut infiltrated and inflamed, constipation becomes absolute. During the earlier stages ineffective painful peristaltic movements occur, which may sometimes be heard as gurgling sounds through a stethoscope placed on the abdominal wall; later, they are abolished. *Thorough paralysis of the gut is not recovered from.* A free movement from the bowels after an operation for peritonitis is a cheering event to both surgeon and patient. Septic peritonitis following abdominal operations of all kinds is occasionally attended by diarrhea of a septic character. Some cases of puerperal septicemia complicated by peritonitis are accompanied by diarrhea during the time when the peritoneum is not extensively inflamed.

Physical Signs of a Peritoneal Exudate.—Determination of the presence of an exudate in the abdomen by palpation and percussion is possible in some cases of peritonitis, not in others. As stated, in peritoneal sepsis, the amount of exudate is often small and gives no physical signs of its presence. In cases of purulent peritonitis of a rapidly progressive character without the formation of distinct loculi of pus walled off by fibrin, it is rarely possible to find flatness on percussion in the flanks, indicating the presence of free fluid. Flatness here may be found, due to coils of gut distended by fluid. Rocking motions may give rise to splashing sounds, indicating a mixture of gas and liquid in the gut. These signs are of but slight value in diagnosis. Pathological and traumatic perforations of the stomach and intestine are sometimes followed by the escape of gas into the peritoneum. The gas tends to accumulate in the upper part of the belly. Absence of liver dullness may thus be caused.

In cases of progressive fibrino-purulent peritonitis with walled-off loculi

of pus, and in cases of localized peritonitis with the formation of a single large abscess, or a massive fibrinous exudate, a distinct sense of resistance, and, in some cases, a sense of elastic fluctuation with dullness or flatness on light percussion, may be present. The rigidity of the abdominal muscles, and the pain caused by the manipulation, often render the examination unsatisfactory. Under a general anesthetic the tense muscles are relaxed, and it is often easy to map out a definite mass of variable size through the abdominal wall. Such a mass may be agglutinated and infiltrated coils of gut covering or inclosing an abscess cavity; tympanitic resonance will then be present over the tumor. It may be an inflamed mass of omentum alone, or inclosing an inflamed appendix and an abscess, or the appendix itself, or some other organ, or a strangulated coil of gut, or a distended gall-bladder, or actually an abscess, a portion of whose boundary is formed by the abdominal wall, or a broken-down new growth, etc. In some cases the surgeon may, from concomitant signs and symptoms, conclude correctly as to the exact nature of the tumor; in others he cannot. (See Diseases of the Individual Viscera.)

Examination Per Rectum or Per Vaginam.—Examination *per rectum* or *per vaginam*—one or two fingers being introduced for the purpose, the other hand being used to palpate the abdominal wall—should never be omitted in peritonitis the origin of which is doubtful. Much valuable information may thus be obtained, and errors avoided. A boggy or fluctuating tumor in Douglas's *cul-de-sac*; lesions of the uterus, tubes, and ovaries; of the bladder, prostate, or seminal vesicles; and many other conditions may be found or eliminated.

The Aspirating Needle and Trocar.—In only a few conditions is the surgeon justified in introducing a needle or trocar through the abdominal wall for the purpose of detecting the presence or character of an acute inflammatory exudate supposed to lie within the cavity of the peritoneum. No information is thus obtainable which cannot be obtained more certainly and with far less danger through a small incision. Certain intra-abdominal organs and lesions may be explored with a needle with safety under certain conditions to be described, notably in abscess of the liver and subphrenic abscess. The exploring needle and aspirating syringe are very rarely used by experienced surgeons to explore either acute or chronic intraperitoneal lesions. The danger of leakage of septic or irritating fluids into free peritoneum after the needle is withdrawn is great; and such leakage is often followed by fatal sepsis or peritonitis.

Danger of Delay in Operating in Cases of Localized Peritonitis.—The diagnosis of a beginning acute peritonitis having been made, it is important to remember that we cannot tell whether the process will remain localized or become diffuse. Postponement of operation in these cases thus involves very grave risks.

Differential Diagnosis.—A number of pathological conditions may simulate beginning peritonitis. When diffuse peritonitis is well developed it is not likely to be confounded with any other disease except acute intestinal obstruc-

tion, since the former may follow the latter; and peritonitis is, as stated, when diffuse, commonly associated with intestinal paralysis and total inability to evacuate the bowels.

Intestinal Colic.—The pain is intermittent, or varies from moment to moment in intensity. Abdominal tenderness is absent; firm pressure on the abdomen often relieves the pain; there is no rigidity of the abdominal wall. The pulse and temperature are not affected; there is no vomiting.

Acute Gastro-enteritis.—There is diarrhea as well as vomiting. The abdominal pain and tenderness are general. There is no localized muscular rigidity. There may, however, be fever and a rapid pulse. Occasionally the leucocyte count may be high, the differential count will fail to show a marked relative increase in the polymorpho-nuclear leucocytes. I have found the following precaution a wise one. *When called to see a patient who has an attack of abdominal pain and vomiting, the physical examination being negative, see and examine that patient again in six hours, and visit him, at suitable intervals, at least twice during the following day. Give no morphin until sure he has or has not beginning peritonitis.* A diagnosis of beginning peritonitis having been made, and operation decided upon, a small dose of morphin may be given if pain is excessive, and the operation is, of necessity, delayed some hours.

Nephritic Colic.—The pain of nephritic colic may be referred to the abdomen in such a way as to suggest peritonitis. There is often vomiting. As pointed out under the diagnosis of Renal Calculus, pain radiating into the groin, testis, etc., is, while characteristic, by no means always present in cases of renal calculus. There will usually be tenderness on deep sudden pressure, or from a light, quick blow over the last rib, when a stone lies in the pelvis of the kidney. Urinary signs and symptoms should be sought for—anuria, oliguria, and abnormal ingredients, especially red blood cells in the urine. Abdominal distention does not develop. The tenderness and rigidity of the abdominal wall are, if present, confined to the region of the kidney, or are felt along the course of the ureter. General abdominal tenderness and rigidity are not present. Careful observation of the case for several hours usually enables us to exclude peritonitis without difficulty.

Uremia.—Uremia is sometimes associated with severe abdominal pain. The local signs of peritonitis are absent. There may be coma or convulsions and suppression of urine. Urine passed, or withdrawn through a catheter, will show the evidences of nephritis—albumen, casts, a low specific gravity, and small content of urea.

Intestinal Obstruction.—Both intestinal obstruction and diffuse peritonitis are accompanied by frequent vomiting. In the former the vomited matter regularly acquires a fecal character after the obstruction has existed for a certain time, and is absolute. In the latter, fecal vomiting is common after the gut is paralyzed. Both are accompanied by distention of the abdomen. In many cases of intestinal obstruction peritonitis finally develops as the result of gangrene or perforation of the gut. The bacteria are not confined by the

intestinal wall when deprived of its vitality, and thus infect the peritoneum. In advanced cases of both conditions it may be impossible to say from the clinical symptoms which of the two was originally present. During the earlier stages of intestinal obstruction, before peritonitis has occurred, a differential diagnosis is usually not difficult.

The abdominal distention in acute obstruction is often localized in some particular part of the belly. Abdominal tenderness is confined to the seat of the obstruction, or if this be deeply placed in the belly, marked tenderness may be absent except on deep pressure. Rigidity of the belly wall is absent or less marked than in peritonitis. The distended coils of gut in obstruction can often be seen and felt if the belly wall is moderately thin. Peristaltic movements are often visible and palpable in the distended coils, and gurgling sounds are apt to be much more marked and distinct on auscultation than is the case in peritonitis, even in its early stage. In obstruction neither feces nor gas are expelled *per rectum*. In peritonitis an enema often brings away some small amount of feces and gas, unless the paralysis of the gut is absolute.

Fever is not present in obstruction unless the peritoneum is inflamed; it is often present in peritonitis. *The pain* of peritonitis is continuous. In the early stages of obstruction the pain is apt to occur in sudden severe attacks corresponding to peristaltic waves, and may even be intermittent. Leucocytosis is, with the exceptions noted, regularly present in peritonitis, absent in obstruction. The general condition of patients suffering from obstruction is at first good; symptoms of progressive prostration increase from hour to hour until death, unless the obstruction be relieved. Cases of peritoneal sepsis, and, in general, all cases of peritonitis due to perforation of the intestinal tract, are suddenly and violently ill from the start. In the cases of gradually spreading fibrino-purulent peritonitis and localized peritonitis this sharp distinction does not obtain.

Localized Peritonitis.—From the foregoing description it may be gathered that the diagnosis of advanced diffuse purulent peritonitis offers no difficulties. Unfortunately, in its later stages, the condition is a desperate one, only rarely to be relieved by surgical means. In order to be efficient, treatment must be applied while the disease is still localized, or before the process—if no limiting adhesions are formed—has produced fatal sepsis or permanent paralysis of the gut. A large proportion of cases of suppurative and perforative lesions of the abdominal viscera are accompanied by peritonitis, at first distinctly localized. In some instances the process remains shut off by adhesions from the general cavity of the belly; in others, sooner or later, becomes generalized; and, in still others, complications of a dangerous or fatal character occur, due to septic thrombosis of veins or to lymphatic absorption. It is, therefore, important that localized foci of suppuration in the cavity of the abdomen should be recognized very early in order that appropriate surgical treatment may be applied.

The *character of the exudate* in localized peritonitis may be serous, fibrinous,

purulent, or putrid, or a combination of these ingredients. In a good many cases a purulent exudate walled off by fibrin may be accompanied by a considerable effusion of serum, free in the peritoneum, as the result of peritoneal irritation. Such serum is often found to be sterile.

The *symptoms* of localized peritonitis resemble at the outset the symptoms of beginning diffuse peritonitis, as already described. The patient is seized with severe abdominal pain and vomiting. The pain, as stated, may at first be general, and is subsequently localized near the seat of the lesion. There is localized tenderness and rigidity of the abdominal wall; the remainder of the abdomen remains soft and not tender. There may be fever, moderate or high, or a normal temperature may be present. The pulse is usually increased in frequency, 90 to 100 to 120 beats per minute, but remains of good quality. Abdominal distention may be absent or moderate. The general condition of the patient remains good. The vomiting may be repeated once or twice, but is not continuous. The inflamed portions of intestine are more or less distended and temporarily paralyzed, but the bowels can usually be moved more or less thoroughly by means of an enema. The patient does not look seriously ill. The expression of the face is not drawn, pinched, and anxious, but calm, even cheerful. An increased leucocyte count with relative increase of the polymorpho-nuclear cells is quite regularly present. If the exudate be fibrino-purulent and completely walled off the leucocyte count may fall nearly to normal, to rise again temporarily after operation. Locally, after the process has existed for a day or two, it is usually possible to discover by palpation a definite intra-abdominal mass, composed of inflammatory exudate and of inflamed and infiltrated tissues and organs, as already noted under progressive peritonitis.

The subsequent *course* of localized peritonitis is very varied. If the exudate is serous and fibrinous merely, the result of mechanical or chemical irritation, or of a septic process in the gut, the appendix, the gall-bladder, the tubes, or other structure, which does not actually infect the peritoneum, the exudate may gradually be absorbed, with subsidence of all the symptoms. Organized adhesions are usually formed, more or less extensively, between the inflamed peritoneal surfaces. These may remain for some weeks or months, and finally disappear; or in other cases remain as permanent bands or thickenings of fibrous tissue, at times thin and fragile, at times dense and firm, according to the intensity of the antecedent inflammation. A thoroughly walled-off purulent exudate, if of small size, may remain innocuous, and finally become sterile. This seems to be especially true of localized purulent exudates originating in the tubes and ovaries the result of gonorrheal infection. It is rare that purulent foci bearing the ordinary pus-producing organisms behave in this manner; the outcome of these is various.

The abscess may increase in size, and slowly or suddenly invade the general cavity of the belly. It may, finally, rupture into the intestine, the bladder, the vagina, the rectum occasionally, with eventual cure. The abdominal

wall may be invaded with the production of a localized abscess or a spreading septic phlegmonous inflammation. Infection of the abdominal lymphatics may occur with the production of abscesses originating in the mesenteric or retroperitoneal lymph nodes. Lymphatic infection of the pleura and pericardium is not uncommon. Infection of the mesenteric veins usually eventuates in a spreading septic thrombophlebitis, finally involving the portal vein and its distribution in the liver, ending in death with pyemic symptoms. Localized peritonitis involving the major part of the coils of small intestine, although the process may be limited above by the omentum and transverse colon, usually gives the signs and symptoms of generalized peritonitis. One of the most serious forms of localized peritonitis is subdiaphragmatic abscess. (See section on this topic.)

Uterine Sepsis.—Septic infections of the interior of the uterus—whether occurring after labor, or as the result of operations upon the interior of the uterus (whether pregnant or not)—may result in septicemia through lymphatic absorption. Peritoneal irritation or inflammation, when present, exists merely as a part of the general infection. The condition is rarely amenable to operative treatment. Less intense infections of the endometrium, whether due to puerperal infection, to operative measures on the interior of the uterus (curettage, cauterizations, irrigations), frequently result in peritoneal irritation or inflammation. The infectious material reaches the peritoneum through the orifices of the Fallopian tubes. The exudate may be serous, fibrinous, or purulent, and may result merely in more or less extensive adhesions, or in the formation of a pelvic abscess. Owing to the proximity of the rectum, these abscesses are frequently infected with the bacillus coli. The pus has then a fetid odor; there may be the formation of gas. Such an abscess commonly forms behind the uterus in Douglas's pouch; less often in front of the broad ligament. Rupture of such abscesses into the gut or into the vagina is not uncommon. The abscess may attain a very large size, fill the pelvis, and present above the pelvic brim as a tender, fluctuating abdominal tumor.

The type of the disease is rather subacute or chronic, a generalized peritonitis very rarely follows. The constitutional infection is seldom marked. These patients are often up and about with a large pelvic abscess. They suffer from pain in the sacral region, sometimes from pressure symptoms upon the bladder and rectum. Elevation of temperature and an increased pulse rate may or not be present. Leucocytosis will be present or absent, according as the process is more acute or chronic, and more or less completely shut off by adhesions. Menstrual disturbances are usually present—pain, menorrhagia, metrorrhagia. Usually, also, endometritis and a more or less profuse muco-purulent discharge from the uterus. I recently operated on a case in which a small pelvic abscess connected with the ovary was ruptured by external violence, an extensive purulent peritonitis followed at once, giving very severe symptoms.

Gonorrheal Peritonitis.—Gonorrheal infection of the pelvic peritoneum is exceedingly frequent in females. Such an infection may occur in an acute

form in a woman previously healthy during an acute attack of gonorrheal inflammation of the endometrium. *Intra-uterine medication or operation is a not infrequent cause of the extension of the process.* In the presence of an acute gonorrhea the patient is seized with violent pain in the lower part of the abdomen, vomiting, prostration, a rise of temperature, an accelerated pulse, together with abdominal rigidity and tenderness which may be on one or both sides of the median line. If the peritonitis proceeds from leakage of gonorrheal pus from the right tube, if the patient is young and, presumably, a virgin, in the entire absence of chronic inflammatory thickening in the tubes, ovaries, and broad ligaments, as determined by bimanual examination, a diagnosis of acute appendicitis will probably be made. I have seen two such cases within the past year. The patients were aged fourteen and sixteen years respectively.

A differential diagnosis is very desirable, since in acute gonorrheal peritonitis operation may sometimes be postponed with advantage. It is therefore very desirable to seek for the presence of gonococci in the discharge from Bartholin's glands, the urethra, and the cervix when any doubt at all exists as to the diagnosis. These patients are generally quite ill; there is no mass to be felt in the region of the appendix. They are not as ill as those who have a diffuse or spreading peritonitis from the ordinary streptococcus and saprophytic infection following perforative lesions of the intestine. Under suitable conservative treatment they quite often improve after some days. A certain number of cases do run a violent and sometimes fatal course, probably as the result of mixed infection. They require immediate operation. In the subacute and chronic forms, gonorrheal pelvic peritonitis existing, as it does, in combination with endometritis, salpingitis (pus-tubes), and ovarian abscess, is a condition so frequent that in any active service in a general hospital in the city of New York one or more of these cases forms almost a daily part of the surgeon's work.

Diagnosis of Pelvic Peritonitis.—Without going particularly into the pathology and symptoms of these cases, it may be said that the diagnosis of pelvic peritonitis depends partly upon a history of infection following labor—natural or induced—an antecedent intra-uterine operation or instrumentation, a history of gonorrheal infection, or of pelvic pain, menstrual disorders—irregular, profuse, and usually painful menstruation—endometritis, pressure symptoms upon the bladder and rectum, partly upon the presence of constitutional symptoms of pyogenic infection in acute cases, partly upon the results of physical examination.

Bimanual Palpation.—The most useful method of examining the pelvic viscera of the female for the detection of inflammatory exudates and other lesions is bimanual palpation, one examining hand being placed on the surface of the abdomen, one or two fingers of the other hand being introduced into the vagina if the patient is an adult woman, or into the rectum if she be a child or young virgin. Nervous patients, virgins, those who have some acute

inflammatory process in the pelvis, stout women with thick abdominal walls, and in all cases where the patient is unable or unwilling to relax the abdominal muscles completely during the examination, can only be examined in a satisfactory manner under a general anesthetic. I am in the habit, in hospital work among such cases, of deferring a thorough bimanual examination until the patient is anesthetized and prepared for any operation which may be found necessary.

In conducting the examination without an anesthetic the patient should be prepared by a previous purgative and enema to insure an empty rectum; the bladder should be emptied just before the examination; all tight clothing—stays and waist bands—should be removed. The patient should be placed in the lithotomy position upon a table the height of which is such that, as the surgeon stands in front of his patient, her symphysis pubis should be on a level a little lower than his elbow. The patient's head and shoulders should be supported by pillows, since by having the upper part of the body a little raised the abdominal muscles are more readily and completely relaxed. The knees and thighs should be strongly flexed and the feet comfortably supported. The feet should be near together rather than far apart, the knees well separated. Due care should be exercised not to offend the patient's sense of modesty. The examination should be conducted, whenever practicable, in the presence of a nurse.

Preceding the bimanual examination the surgeon puts on sterile rubber gloves, or, if these are not obtainable, he washes and disinfects his hands by one of the several known methods. The external genitals are inspected. The existence of a purulent discharge from Bartholin's glands and from the urethra is strongly suggestive of gonorrhea. Each gland is gently pinched between the finger and thumb, and the urethra milked by a forefinger introduced into the vagina and pressed upward against the pubes. If a drop of pus appears in either case, microscopic examination will usually show the presence of the gonococcus; a purulent discharge from the cervix may be due to a similar cause. A bloody, brown, and foul-smelling discharge is strongly suggestive of cancer. A scanty, bloody discharge, with a cadaveric odor, with a history of a recent labor or abortion, indicates sapremia from retained placenta or blood clot.

The index and middle finger of one hand (or the index alone), being lubricated, are introduced into the vagina. The palpation of the pelvic organs by the vaginal fingers is made with the palmar surface of the tips of the fingers; in order to reach deeply into the pelvis, a good deal of pressure must sometimes be exerted. The perineum and floor of the pelvis must be invaginated to some extent. In order to accomplish this properly, and at the same time preserve the mobility of the examining fingers, the surgeon rests his elbow against his own pelvis and pushes forward his forearm and hand by the weight of his body. The thumb of the vaginal hand rests against the pubes; the fourth and fifth fingers may be strongly flexed or widely abducted, and held

against the perineum. The palmar surface of his other hand is used to depress the abdominal wall just above the pubes so that the pelvic organs can be brought successively between the two hands, and their form, position, size, consistence, mobility, sensibility noted. The outside hand is used rather as a point of support against which the vaginal fingers pass the pelvic viscera in review.

A moderate amount of practice only is necessary to enable one to map out clearly the normal pelvic viscera, provided the manipulations are conducted in the right way. The alterations produced by disease are some of them easy, some of them difficult to recognize without a good deal of experience. The reader is referred to works on gynecology for the details of diagnosis in uterine displacements, etc. If the patient holds the abdominal muscles rigid, she may be told to breathe through the mouth. In the case of young virgins and children, a very satisfactory examination may be made through the rectum. For a thorough examination a general anesthetic is most desirable in many cases. In normal and not neurotic or hysterical women, a complete pelvic examination may be made without causing pain unless the ovary be rather severely pinched. In all inflammatory conditions this will not be the case.

Fixation of Pelvic Structures.—A common character of all cases of acute or chronic pelvic peritonitis is loss of or diminished mobility of the pelvic organs. This may be slight and confined to one tube or ovary, or, in old and extensive cases of gonorrheal peritonitis, when frequently repeated outpourings of infectious pus have occurred from the mouths of the Fallopian tubes, the entire contents of the pelvis may be cemented together into a firm, hard mass in which the separate viscera can in no wise be differentiated except by a careful intra-abdominal dissection. In the history of these cases the patients will complain of severe attacks of abdominal pain, recurring at intervals during a period of years, sometimes accompanied by vomiting, and usually referred to indiscretions in diet, to taking cold, overfatigue, and the like. The condition long ago received a special name—"Colica scortorum" (harlot's colic). The surgeon will do well to remember that such attacks are by no means confined to this class.

Upon examining such a case the uterus will be found immovable, the pelvic floor everywhere hard and boardlike; the abdominal hand will meet a diffuse sense of resistance extending across the brim of the pelvis. In many of these cases abscess will be present. The most common location for the accumulation of pus is the Douglas pouch; in such cases a boggy or fluctuating area may be felt behind the cervix, or a distinct bulging in this region may be felt, and even seen, by placing the patient in the genu-pectoral position and introducing a speculum into the vagina. The viscera tend to fall toward the diaphragm, air enters the vagina, and distinct bulging in the posterior fornix may be visible. The diagnosis may be confirmed by the introduction of an aspirating needle, if desired. In other cases the abscess will be wholly or partly included in the ovary, or its walls may be formed by the ovary, tube, and broad ligament,

or the posterior surface of the uterus; rarely by the anterior surface of the uterus, broad ligament, and bladder. Under anesthesia these various conditions may be mapped out more or less clearly by vaginal or rectal touch, combined with abdominal palpation. Pain, tenderness, and abdominal rigidity make a thorough examination rather difficult when the patient is conscious.

In some cases, not so far advanced, the surgeon's fingers will pass from the fundus of the more or less movable uterus outward, and feel on one or both sides the enlarged and thickened tube. Such a tube may feel like a hard, firm, cylindrical cord, of variable size and length, or as a large sausage-shaped tumor, thicker than a man's thumb. Such a tube may be adherent or free, and can usually be traced outward or backward into an enlarged and fixed ovary. Gravity frequently causes the inflamed tube and ovary to fall downward and backward in Douglas's pouch, there to become adherent. Considerable backward rotation of the tube and ovary commonly occurs, so that in many cases the tube and ovary come to be wrapped up in the broad ligament, and to lie as a conglomerate mass buried in adhesions behind the uterus at the bottom of the pelvis. A knowledge of this rotation enables the surgeon to untwist an apparently hopeless tangle with comparative ease when removing the diseased structures. In all these cases the rectum, the sigmoid flexure of the colon, and coils of small intestine are all likely to become adherent to the inflamed uterine appendages, and the walls of abscess cavities are not infrequently formed in part by coils of intestine.

The right tube and ovary when inflamed often become adherent to the vermiform appendix and drag this structure down into the pelvis. The appendix may thus become involved in the inflammatory process, and be found at the operation incorporated in an inflammatory mass consisting of tube, ovary, and appendix. In these cases the diagnosis of the true state of affairs may be puzzling before opening the abdomen. Symptoms and signs of chronic appendicitis and of disturbances of the sexual organs, together with attacks of pelvic peritonitis, may all be present. Fortunately the right tube and ovary, together with the appendix, can all be removed through an intermuscular incision in the right lower quadrant of the belly unless the abdominal wall be very thick. In such cases a median cut may be necessary.

Localized Peritonitis Secondary to Inflammations of the Gall-bladder.—Localized peritonitis is often secondary to inflammations of the gall-bladder, caused usually by gall-stones. Infection of the wall of the gall-bladder leads to peritoneal irritation, a fibrinous exudate, and the formation of adhesions which often involve the gall-bladder, duodenum, pyloric end of the stomach, right border of the omentum, and splenic flexure of the colon. Pain and tenderness will be present below the costal border, at the outer border of the right rectus muscle. If the gall-bladder is perforated, an abscess will form in the same region, and will give the signs and symptoms of localized peritonitis. An inflammatory tumor will be present below the ribs on the right side. The constitutional symptoms of sepsis will be more or less

marked. (See Diseases of the Biliary Passages. See, also, Subphrenic Abscess.)

Localized Peritonitis Caused by Lesions of the Pancreas.—Necrotic and suppurative lesions of the pancreas may cause a local peritonitis behind the stomach in the lesser peritoneal sac. (See Diseases of the Pancreas.)

Subphrenic Abscess.—Localized peritonitis of the lower surface of the diaphragm with the formation of a walled-off abscess, bounded below by the liver, or by the liver and other adjacent viscera, may occur as a part of the generalized peritoneal infection—notably of the progressive fibrino-purulent type—or secondary to injuries and suppurative or perforative lesions of certain of the viscera, notably the liver and gall-bladder, stomach, duodenum, transverse colon, vermiform appendix, spleen. The omentum and transverse colon act, in many cases, by forming adhesions with the abdominal wall, as a dam to prevent the spread of infectious material upward from the lower part of the belly. In the case of the appendix, pus may travel upward along the colon to the liver, or in the loose tissues behind the colon to the right border of the liver, and thence infect the diaphragmatic peritoneum. On account of the suspensory ligament of the liver which separates the subdiaphragmatic space into two parts, lesions of the appendix, right lobe of the liver, gall-bladder, and right kidney are apt to produce an abscess on the right side, while lesions of the stomach, duodenum, left kidney, pancreas, and spleen usually infect the left half of the diaphragm.

Infected wounds of the liver and suppurative processes of all kinds in the liver or biliary passages readily reach the diaphragm either by superficial extension or perforation of the liver tissue. Slowly perforative lesions of the stomach and duodenum, with the formation of limiting adhesions, may spread to the upper surface of the liver, usually upon the left side, sometimes upon the right. Ulcerative lesions of the lower end of the œsophagus and empyemata, notably of the putrid variety, may penetrate the diaphragm and cause a localized infection of peritoneum. Infectious lesions of the spleen, the kidneys, the pancreas, may all give rise to subdiaphragmatic abscess, as may osteomyelitis of the ribs and of the dorsal vertebræ. In many cases the pus of these abscesses is infected with the saprophytic germs of the intestinal tract, leading to the formation of gas; the pus will have a putrid odor in such cases. An important and frequent complication is serous or purulent pleuritis. Infection of the pericardium is not very rare.

Symptoms and Diagnosis of Subphrenic Abscess.—When the subphrenic abscess occurs as the immediate result of a wound or perforation of the stomach or duodenum, or exists as a part of a progressive fibrino-purulent peritonitis, the signs and symptoms of acute peritoneal irritation—pain, fever, localized tenderness, leucocytosis, vomiting, etc.—together with special signs and symptoms about to be described, usually attract the surgeon's attention to the subdiaphragmatic space. When, on the other hand, as is quite often the case, the abscess develops as a rather late complication of an acute localized peritonitis

days or weeks after an operation for appendicitis or cholecystitis, or when a gradual extension of a subacute purulent focus in some neighboring structure or organ infects the lower surface of the diaphragm, the abscess often develops insidiously without producing any marked local or general symptoms to indicate its presence. Its existence may then remain unsuspected for a good while.

It will be noticed that the patient is not doing quite well. He has a moderate rise of temperature in the evening; his pulse remains a little rapid. He may sweat at night. His appetite is poor. He may have a little dyspnea. The operation wound, if such be present, may have healed or may be slightly infected or sluggish. Leucocytosis of a moderate grade may be present or the count may be normal. There is no abdominal distention; the belly remains soft and flaccid. Careful inspection will show a greater or less degree of immobility of the costal margin and lower ribs on one or other side. There may be neither pain nor tenderness. When the fluid collection has become large there may be distinct bulging of the chest wall.

The diagnosis of the exact condition is, in some cases, easy from the history and the physical signs; in other cases it will be quite difficult. In these cases the use of an aspirating needle is justifiable, and of great aid in the diagnosis. The history of these cases will usually include a recent injury to the upper part of the abdomen, an attack of appendicitis, a cholecystitis, or the performance of an operation for one of these conditions, or a history of gastric or duodenal ulcer, etc.

The *physical signs* vary a good deal in different cases, and are sometimes puzzling. In a typical case upon the right side, the liver is displaced downward, the diaphragm upward. The lower border of the liver will usually be palpable below the free border of the ribs. The liver dullness in front will be increased in percussing from above downward; there will be pulmonary resonance above, then dullness or flatness to the lower border of the liver. The line of dullness above will be, in some cases, distinctly arched from side to side. If, as is usual upon the right side, gas is present as well as pus, there will be from above downward pulmonary resonance, a belt of tympanic resonance more or less broad, and below that flatness to the lower border of the liver. In some cases, if the purulent collection is localized in the posterior part of the space between the liver and diaphragm, displacement downward of the anterior border of the liver may not occur. Upon auscultation there will be normal or exaggerated breathing over the lung, both before and behind, and a sharp boundary line below which breathing is absent. If, as sometimes happens, there be a pleurisy with effusion upon the same side, the signs posteriorly will often be confusing.

The introduction of a long aspirating needle is the best means of arriving at a diagnosis. The needle may be introduced into the area giving flatness on percussion, in the axillary line or in the scapular line, or even in front in some cases, sometimes at the point of greatest tenderness. If the first puncture

fails to withdraw pus, the needle should be reinserted in several different situations. As the needle is slowly pushed onward, the piston of the syringe is drawn out a little from time to time. It is usually possible to distinguish the sense of resistance produced by the diaphragm. If there be pleurisy with effusion, the needle will withdraw serum and, at a deeper level, pus. If there be empyema, the diagnosis of subphrenic abscess will probably not be made until the case is operated upon, when the upward bulging of the diaphragm may suggest abscess of the liver, subphrenic abscess, or echinococcus cyst. The appearance of the pus in abscess of the liver is more or less characteristic. It is thick, dark in color, resembling chocolate; fragments of liver tissue are to be recognized under the microscope. The pus of an ordinary empyema is usually creamy and yellow. The fluid of echinococcus cysts, if not infected, is clear, straw-colored; the hooklets can be discovered under the microscope. The presence of gas, with pus and a foul odor, will indicate subphrenic abscess or putrid empyema.

I once saw a fluid accumulation between the right lobe of the liver and the diaphragm following a subcutaneous injury which had produced a moderate laceration of the upper surface of the liver. The fluid was entirely shut off from the rest of the belly by adhesions between the anterior border of the liver and the abdominal wall. The fluid was thin, blood-stained, and contained numerous flakes and masses of fibrin. The collection was entirely aseptic. The physical signs indicating a subphrenic accumulation were present.

Upon the left side subphrenic abscess follows perforation of the stomach and duodenum more often than other lesions. When these perforations are not followed by general infection of the peritoneum they produce an abscess which usually gives all the signs of acute peritoneal irritation, followed by marked constitutional symptoms of sepsis and all the local signs and symptoms of localized purulent peritonitis, as already described. There will often be a distinct prominence in the epigastrium, over which the abdominal wall is rigid and tender. The liver will in some cases be displaced downward, and may be palpable. The heart is displaced upward. In the presence of such signs and symptoms the indications for opening the abdomen are quite plain. In other cases the disease may develop in a subacute manner, following gradual perforations of the stomach and duodenum or infectious processes of the pancreas, kidney, and spleen, or one of the other conditions already mentioned.

In these cases the physical signs may be important aids in diagnosis, but are quite often confusing. Abscesses on the left side, arising, as they do in a large proportion of cases, from the stomach and duodenum, frequently contain gas. The percussion note posteriorly may, as upon the right side, exhibit the following qualities: normal resonance over the lung above, tympanitic resonance over the gas, and dullness or flatness over the pus. The respiratory murmur ceases abruptly below. As upon the right side, the presence of a pleuritic exudate renders the physical signs uncertain. The aspirating needle may be used with more caution than upon the right side to aid the diagnosis.

In the presence of a large quantity of gas and pus the level of the flatness or dullness may change upon changing the position of the patient. The stomach should be emptied by a tube when making this examination lest its fluid and gaseous contents cause confusion of the signs.

Chronic Peritonitis.—Chronic peritonitis may be described as existing in two forms: (1) an exudative chronic peritonitis; (2) chronic peritonitis, with the production of adhesions.

(1) Chronic Exudative Peritonitis (Vierordt, A. Fraenkel, Lennander).—Chronic exudative peritonitis is identical clinically with that form of tuberculous peritonitis accompanied by a large accumulation of serous fluid in the belly. The resemblance is the more striking because nodular masses in the omentum are said to form in chronic exudative peritonitis—a striking character, also, of this form of tuberculous peritonitis. The condition appears, however, to be a well-recognized one, many cases having been described. The disease begins without apparent cause, usually in young persons of the female sex. These patients become pale and anemic; they lose flesh and strength. Gradually an accumulation of fluid occurs in the abdomen, usually without pain or tenderness, although such may exist. The fluid may increase to a large amount, and produce pressure symptoms upon the diaphragm. The bowels may be constipated. Nodular masses may be felt in the omentum. It is necessary to exclude tuberculous peritonitis, ascites from heart disease, or cirrhosis of the liver, and serous effusion accompanying malignant disease of the abdominal viscera. (For the physical signs, see Ascites.) The disease is said to get well in some cases without surgical treatment. Upon opening the abdomen, the only lesions found have been the serous effusion and the thickenings of the omentum. Evidences of tuberculosis have been wanting and inoculations of susceptible animals have been negative.

(2) Chronic Peritonitis, with the Production of Adhesions.—This form of peritonitis may follow injuries and acute inflammations of the peritoneum from any cause, or may apparently arise as an independent condition. Intraperitoneal organs, in abnormal situations and subjected to mechanical irritation, portions of omentum and coils of intestine retained in hernial sacs, quite regularly are the seat of this form of peritonitis. It may be a localized or general process. When localized, the favorite sites of the lesion are in those parts of the belly most often the seat of acute inflammatory processes—the female pelvic peritoneum, the right iliac fossa, the region of the duodenum, gall-bladder and pylorus, the root of the mesentery, the flexures of the colon. The localization renders it probable that in most instances the peritoneal irritation has originated in some acute or chronic inflammatory focus. The lesion consists in the formation of plaques, masses, and bands of fibrous connective tissue, which bind the peritoneal surfaces together either over broad areas or through the medium of cords or bands. In some cases a large part of the peritoneal space is obliterated, in others dense masses of fibrous tissue cement the viscera of a region into a solid mass. (See Pelvic Peritonitis.) Contrac-

tion of the new-formed tissue, as time goes on, causes deformities of organs, interference with the mobility of the alimentary tract, disturbances of its function, localized diminution of its caliber, not infrequently sudden and complete obstruction, and furnishes the mechanical factors necessary for the production of torsions of the gut, obstruction by bands, and other dangerous and fatal conditions. As stated, chronic adhesive peritonitis may originate *de novo* at any time of life. In many cases it follows traumatisms of the belly, either accidental wounds or operations involving the peritoneum—notably when extensive handling has been necessary. The majority of the cases, however, follow acute inflammatory processes in the abdomen of an infectious character irrespective of whether they have been operated on or not. It may be due to late syphilis of the gut.

The symptoms cannot be described categorically, since they will vary with the organs or structures involved, and with the nature of the mechanical interference with their function. There may be no symptoms for years; suddenly the bowel may become twisted upon itself or kinked, a loop of gut may pass beneath a band joining two adjacent peritoneal surfaces, and become constricted or kinked; in either case the symptoms are those of acute intestinal obstruction. Adhesions in the neighborhood of the gall-bladder and stomach may cause digestive disturbances and pain when these structures are thrown into activity by the ingestion of food. Adhesions about the colon may give rise to constipation and to attacks of severe colic. Adhesions in the female pelvis give rise to constipation of the bowels, to displacements and deformities of the pelvic viscera, and to painful, excessive, or irregular menstruation.

In determining upon the question of operative relief in these cases the surgeon must be guided by the previous history of injury or acute inflammation, by the nature and gravity of the functional disturbances, by the location of former operative scars, and by the nervous condition and mental attitude of the patient. In cases of acute obstruction, whether or not immediately or remotely related in time to an abdominal operation, no delay is permissible; a postponement of operative interference for a few hours may determine the death of the patient. When the adhesions cause functional disturbances merely, the patients often become neurasthenic. Some of these cases can be cured or improved by operative liberation of the adherent peritoneal surfaces, removal of bands, etc.; some cannot. In a good many cases the adhesions reform and the symptoms return. I recall a boy who had intestinal obstruction from bands following an operation for acute appendicitis. During the following two years he had intestinal obstruction three times. Following the fourth operation he died of paralysis of the gut, as the result of delay in presenting himself for treatment—the operation was done too late.

Tuberculous Peritonitis.—In acute general miliary tuberculosis miliary tubercles are found in the serous membranes, including the peritoneum; the condition is without surgical interest. As a localized process, tuberculous peritonitis is commonly described as occurring in three forms. The several types

often coexist, or develop one from the other. Tuberculous peritonitis (1) with abundant serous exudation; (2) with the formation of diffuse infiltrations and of nodular masses of tubercle tissue in the omentum, the mesentery, in the wall of the gut, and on the abdominal wall. Contraction of these infiltrations produces shortening of the mesentery and obliteration of its peritoneal folds; the omentum is converted into a firm, knobby mass of tuberculous nodules. Adhesions may occur between adjacent peritoneal surfaces, with partial obliteration of the peritoneal cavity. (3) With the formation of abundant adhesions and of walled-off collections of caseous and broken-down fluid tuberculous detritus. The peritoneal cavity is commonly obliterated. The first form is the only one usually amenable to successful surgical treatment. The lesion consists in an abundant serous exudate into the peritoneal cavity. In some cases the picture is simply that of ascites; no masses of tuberculous infiltration are palpable through the abdominal wall; in others, a combination with the second type exists. The peritoneal surfaces are more or less densely studded with submiliary tubercles and larger nodules of tubercle tissue. Tuberculous infiltration, nodular thickening, and shrinking of the omentum is a characteristic lesion. The omentum is converted into a more or less irregular or sausage-shaped tumor lying transversely across the abdomen, usually at or above the level of the umbilicus, readily palpable through the abdominal wall as a firm mass, somewhat tender and slightly movable. There may be palpable masses in the mesentery, in the wall of the gut, notably in the cecum, and elsewhere. In other cases there will be no fluid in the belly; there will be masses of tuberculous infiltration palpable here and there, but upon opening the abdomen no fluid will be found; the peritoneal cavity may be obliterated by adhesions. In other and rather acute cases the abdomen is nearly dry; the peritoneal surfaces are everywhere reddened, and densely studded with countless tubercles varying in size from a pin's head to a grain of rice. In the third form the peritoneal cavity is obliterated; the intestines are firmly adherent in an inextricable mass. Between the adherent coils here and there in the abdomen there are collections of cheesy material and tuberculous pus; such collections may attain a large size, and may thus simulate cystic tumors of organs.

Symptoms and Diagnosis.—Tuberculous peritonitis is rarely a primary affection, but is usually associated with tuberculosis of the lungs, the lymph nodes, the bones, the joints, the kidney, the female generative apparatus (tubes). In not a few cases the disease appears to be primary in the wall of the gut, notably of the cecum and vermiform appendix; these cases are easily mistaken for malignant disease of the intestine. The existence of other tuberculous lesions or characteristic scars is often an important aid in diagnosis. The patients are commonly young children or young adults, though older individuals are not exempt. Women are more often affected than men. In a good many cases the disease is due to extension from the uterus and tubes, occurring in virgins or parous women. Infection may immediately follow labor. The course is chronic, sometimes with acute exacerbations. In

most of the cases there is a history of gradual loss of flesh and strength; the patients become anemic. There may be a moderate daily rise of temperature or none. Moderate leucocytosis may be present, but in uncomplicated cases the polymorphonuclear cells will not be relatively increased. When there is fever the pulse will be accelerated. When serous effusion is abundant, diaphragmatic breathing may be interfered with and the breathing rapid; severe dyspnea may even be present from overdistention. In the first group of cases the presence of free fluid in the belly will give the ordinary signs—namely, the abdomen is generally and evenly distended, the umbilical pit is often obliterated, the umbilicus may even protrude, dullness or flatness on percussion in the flanks, tympanitic resonance in front. The line of dullness may be made to vary its position by rolling the patient on his side. If much fluid is present and the intestines are held away from the abdominal wall by a contracted infiltrated mesentery, there may be flatness on percussion in front, simulating a large ovarian cyst. An encapsulated collection of tuberculous pus may give rise to a similar impression. When the fluid is serous and free, if one hand is placed upon the flank while the opposite side of the abdomen is sharply tapped, a sensation of a fluid wave will be transmitted across the abdomen. The abdominal wall is soft, the extreme tenderness and rigidity of acute peritonitis are absent. There may be moderate tenderness if nodular masses are present in the abdomen. The pain complained of by these patients is not usually continuous nor very severe unless the functions of the gut are interfered with by adhesions. Attacks of colicky pain, and even total ob-

Fig. 256.—Tuberculous Peritonitis with Abundant Serous Exudation in a Child. (New York Hospital collection.)

struction, may occur in such cases. The function of the alimentary canal may be interfered with in various ways. There may be exhausting diarrhea. If the motions of the intestine are interfered with by adhesions or contractions of the mesentery there may be marked constipation—even, as stated, total obstruction. The serous accumulations may be differentiated from cirrhosis of the liver by the age of the patient, and the absence of an alcoholic history. In cirrhosis, enlargement of the spleen is usually present. There is often jaundice, a change in the size of the liver, vomiting of blood, nosebleed, hemorrhoids, enlargement of the superficial veins of the abdomen, gastritis, etc.

The ascites accompanying valvular disease of the heart is accompanied by valvular murmurs, changes in quality of the heart sounds and in the size of the heart. The serous and bloody peritoneal effusions accompanying some cases of carcinoma and sarcoma, with invasion of the peritoneum, are usually accompanied by a more profound cachexia; a large parent tumor is usually discoverable. The age of these patients is commonly advanced. There will be cases where the surgeon will be puzzled until the abdomen is opened. Those cases arising from the tubes will show inflammatory thickening and deformity of these structures on bimanual palpation. Perhaps the most puzzling cases of tuberculous peritonitis are those arising from tuberculous infiltration of the wall of the cecum and in the vermiform appendix. The condition, in some cases, will be mistaken for chronic appendicitis, with the production of adhesions. In other cases the infiltrated cecum forms a large, nodular, hard tumor in the right iliac fossa, which closely simulates a malignant growth. No positive diagnosis is apt to be made in these cases in the absence of other evidences of tuberculosis until the abdomen is opened. When the tuberculous ulceration and perforation of the gut occur, acute progressive purulent peritonitis, or a localized peritonitis surrounding an abscess cavity, will give the signs and symptoms of the complicating infection in addition to those already present. I have happened to operate on a number of these cases; the situation is gloomy as far as eventual cure is concerned. A tuberculous artificial anus is quite apt to follow resection of the tuberculous gut.

Aseptic Peritonitis.—The peritoneum reacts promptly to all forms of mechanical and chemical irritation by throwing out an exudate which may be serous, fibrinous, or consist of serum stained with blood; so long as no active germs are present, pus is not formed. The end result of such irritations is the production of adhesions; these may be absorbed after a time or be permanent. Aseptic peritonitis occurs as the result of aseptic injuries to the peritoneum, whether accidental or made during the performance of surgical operations. The irritation produced by aseptic fluids—bile, blood, the contents of cysts, small quantities of aseptic urine—has a similar effect. Portions of tissue deprived of nourishment by ligatures, cauterizations, or crushing, cause the formation of adhesions. Cysts with twisted pedicles, strangulations of portions of the intestine before the gut has lost its vitality, volvulus, intussusception, and numerous other like conditions, all may produce a serous or fibrinous exudate, assuming that no bacteria are present. The various chemical antiseptics act in a similar manner. Aseptic foreign bodies—drainage-tubes, gauze packings, ligatures—all are rapidly surrounded by a fibrous exudate and adhesions, when left in the peritoneum. The symptoms of aseptic peritonitis may be quite marked; there may be pain, abdominal distention and rigidity, vomiting, even paralysis of the gut. Septic symptoms are wanting. The process usually ends in resolution and recovery so long as the exudate remains free from pyogenic germs. As stated, the adhesions formed may be absorbed or remain indefinitely.

Injuries of the Peritoneum and Abdominal Contents.—The dangers of injuries of the abdomen are chiefly two: *bleeding*, and *peritonitis* from a wound or rupture of one of the hollow organs of the belly and the escape of infectious material into the peritoneal cavity. Intra-abdominal conditions are favorable for the continuance of bleeding. The blood-vessels of the omentum, mesentery, stomach, and intestine, as well as the great vessels of the abdomen, lie in loose tissues; the blood can flow freely into the cavity of the peritoneum without resistance, and fatal hemorrhage may take place from a surprisingly small source. Wounds and ruptures of the solid organs, liver, and spleen bleed very rapidly, as a rule. Wounds and ruptures of the kidney vary a good deal in this respect, dependent upon the direction and extent of the injury. Wounds of omentum may rarely cause fatal hemorrhage. I recall the case of a young man who was stabbed with a penknife in the lower epigastrium, and who developed the symptoms of abdominal hemorrhage; upon opening the abdomen, but little free blood was found in the belly. The wound in the abdominal wall corresponded to the situation of the gastrocolic omentum. The bleeding had taken place into the substance of the omentum, and the blood had infiltrated and dissected its way widely beneath the peritoneum. The gastrocolic omentum, the transverse colon, and the great omentum were greatly swollen, infiltrated with blood, and converted into a spongy mass which bled freely wherever handled. It was impossible to determine the situation of the wounded vessel. The gastroepiploic arteries were secured, but the bleeding continued in spite of the ligation of tissues *en masse* and other devices, until the patient's death the following day. Many wounds of the omentum bleed only moderately, and it is exceptional that death is due solely to this cause. In general it may be said that dangerous intra-abdominal bleeding occurs most often from wounds of the solid organs and from the mesentery rather than from wounds of the wall of the stomach and intestine. The great vessels of the belly and their named branches will, if wounded, cause fatal bleeding so rapidly that they rarely come under surgical treatment.

A very large proportion of penetrating wounds of the abdomen, whether they are incised, punctured, or gunshot wounds, injure the abdominal viscera. The alimentary canal is more often injured than other organs. The escape of intestinal contents is regularly followed by fatal peritonitis. In some wounds of the intestine, whether punctured or gunshot, if the wound be not very large, prolapse of the mucous membrane of the gut may temporarily and rarely, even permanently, occlude the opening so that only a localized adhesive peritonitis or a localized abscess results. Such an occurrence is exceptional. In the larger number of cases escape of intestinal contents takes place, and diffuse purulent peritonitis is developed in a few hours. Some variations occur in the rapidity with which the signs and symptoms of peritonitis appear, depending upon the part of the alimentary tract wounded and the amount and character of its contents at the time of its injury. The contents of the small intestine (jejunum and ileum) are always fluid and always highly infectious;

a rapid leakage and a virulent peritonitis are to be expected after wounds of this part of the gut. The stomach, on the other hand, may be full or empty at time of wounding; hence, a rapid leakage and an active peritonitis will occur in some cases, a tardy and perhaps less violent inflammation in others. The prognosis of untreated wounds of the stomach is in general very bad. The escape of the contents of the duodenum is not, in my experience, followed by so virulent a peritonitis as occurs from wounds of the ileum. The contents of the colon are sometimes fluid, sometimes solid; leakage may be rapid or slow. Wounds of the extraperitoneal portions of the ascending and descending colon may be followed by slow leakage and the gradual formation of an abscess or phlegmonous inflammation of the loin. The abscess cavity will contain pus, fecal matter, and gas. It is to be remembered in regard to the prognosis of penetrating wounds of the abdomen that sharp instruments may partly divide the coats of the gut, and that blunt instruments may contuse the wall of the intestine. In either case sloughing and perforation may occur many days after the injury. In open wounds of the belly a third risk is also present, namely, the infection of the peritoneum by the instrument which created the wound, or subsequently by the clothing, by germs upon the skin, by unclean hands, instruments, etc. The abdominal wounds made by the surgeon are protected as far as may be from infection. Accidental wounds are exposed to infection by injudicious handling and exploration without due aseptic precautions. The peritoneum is, as stated, quite resistant to infection, as is abundantly shown, by the behavior of operation wounds. The external wound may become infected and the peritoneum escape if closed off mechanically or by a fibrinous exudate. Once infected, the conditions are as favorable for the spread of the process after traumatic as after pathological lesions.

Penetrating Wounds of the Abdomen—Symptoms and Diagnosis (see also Wounds of the Abdominal Wall).—As a matter of practical detail, it may be stated that the examination, exploration, and treatment of penetrating wounds of the belly, or of those in which penetration is suspected or possible, should be undertaken, even at the risk of some delay, with all the careful preparation which precedes the most elaborate abdominal operation. Only in this manner can danger from infection from without be avoided, and only thus can the often unexpected dangers and difficulties of a serious visceral injury be met and overcome. All preliminary probing and fingering are to be condemned as unnecessary, useless, and dangerous. When a wound is known to penetrate the belly, the less the patient is moved about the better. In carrying and transporting such an individual, the utmost gentleness possible under existing conditions is imperative. Necessity and occasion may arise when these precepts cannot be carried out. The surgeon must then do the best he can with the means at hand, and much may be done if only cleanliness can be maintained. Incised wounds of the peritoneum, suitably placed, are often followed by prolapse of the viscera, most often the omentum, which may find its way through a very small wound, and regularly, also, the intestine if

the wound is larger. These structures, if exposed to the air for a few hours, become covered with fibrin and assume a dirty gray color. The intestine is readily recognized, and the omentum also from the characteristic lobulated fat which it contains and the delicate structure of its connective-tissue framework. Only rarely could a projecting tab of subcutaneous fat be mistaken for it. If it be omentum, gentle traction will draw it farther out of the abdomen. The solid viscera only rarely protrude through an accidental wound. The liver and spleen are readily recognized by their consistence, color, shape, and anatomical situation. Occasionally, as the result of an incised wound, a considerable quantity of small intestine may escape from the belly, and such intestine may be extensively torn, contused, or cut. The diagnosis is to be made by inspection. I recently operated upon such a case.

A man stabbed his wife in the abdomen with a carving knife, turning the blade as he withdrew it. A wound about two and a half inches in length and angular in shape was produced to the right of the umbilicus which severed about two thirds of the belly of the right rectus muscle. The woman was brought to the hospital very soon after the wounding and taken at once to the operating room, less than forty minutes from the receipt of the injury. The symptoms of shock were moderate; she had vomited once. Upon removing her clothing a large mass of small intestine was found outside the abdomen, smeared with intestinal contents and much blood. The prolapsed coils measured about five feet in length. There were five incised wounds of the gut—three of them transverse cuts about an inch in length. Two almost completely severed the intestine. There were two incised wounds of the mesentery. The intestines were washed, the bleeding from the mesentery controlled, the intestines sutured and again washed. Upon exploring the interior of the belly no further injuries were found, nor was the peritoneum soiled. The intestine was returned to the belly and the external wound partly sutured. The patient made a prompt recovery.

From some wounds of the belly which open the hollow viscera a discharge may take place of a character indicating the organ wounded; thus, the escape of gas or of intestinal contents would indicate positively a wound of the stomach or intestine; an escape of bile, a wound of the gall-bladder, the bile ducts, the liver, possibly the duodenum; an escape of urine, a wound of the urinary bladder, ureter, or kidney, according to the anatomical site of the wound. While such signs are positive and reliable when present, their occurrence is not constant, and their appearance is not to be awaited as a means of diagnosis.

When, from the history of the case and the appearance of the external wound, it seems doubtful whether the peritoneum has been opened or not, the safest and surest means of diagnosis is to explore the wound with the most careful aseptic precautions. If retraction of the wound edges and the introduction of a sterile gloved finger still leaves the matter in doubt, the patient should be put under a general anesthetic and the wound enlarged sufficiently to settle the question of penetration. If penetration exists, the presence of

blood, intestinal contents, gas, bile, or other material will indicate injury of the blood-vessels or viscera, as the case may be. If no foreign material is found, the structures underlying the wound in the belly wall should be carefully inspected. If no injury of the viscera be discovered and no symptoms have previously existed indicating such, the wound may be closed, with such drainage as seems necessary for the given case.

Stab and Gunshot Wounds of the Abdomen.—The diagnosis of penetration and of visceral injury can often be made in the case of incised wounds of the abdominal wall upon inspection. Such is less often the case in stab and gunshot wounds. In these latter we are often able to infer penetration, intra-abdominal hemorrhage, or visceral injury. From the situation and direction of the wound or wounds, from the character of the weapon or missile, from powder marks upon the skin or clothing indicating close range and probable penetration, from the degree of violence used, and from local and general symptoms exhibited by the patient. We have already described the symptoms of abdominal shock. Such symptoms are usually marked after severe contusions of the abdomen, notably those accompanied by rupture of the viscera. They are commonly present after gunshot wounds, especially after wounds of the stomach. They have been absent in several stab wounds I have seen with injury to the liver, intestine, kidney, and other organs, though in other similar cases they have been present. The presence of shock bespeaks the probable existence of serious intra-abdominal injury.

Symptoms of Intra-abdominal Bleeding.—The symptoms of intra-abdominal bleeding are increasing pallor of the skin and mucous membranes, a progressive increase in the pulse rate. The radial pulse becomes more and more feeble and compressible; coldness of the extremities, sometimes a cold and clammy perspiration, restlessness, thirst, anxiety, air-hunger, syncope, sometimes vomiting. Locally, there is *severe abdominal pain and tenderness*, sometimes localized or general rigidity, rarely noticeable distention. There may be dullness in the flanks and other signs of free fluid in the belly if the hemorrhage is very large. When the blood collects in the region of the spleen, below the right lobe of the liver, in the pelvis, in the lesser sac, or behind the peritoneum, there may be the formation of a more or less defined palpable mass or sense of resistance in the abdomen, dull or flat upon percussion. Such a mass may slowly or rapidly increase in size for several days if the patient survives and is not operated upon. As the blood partly coagulates or is shut in by adhesions, the boundaries of the tumor become more distinct. Such signs are more often observed after subcutaneous injuries than after stab and gunshot wounds, since the latter are more commonly subjected to early operation.

Signs and Symptoms of Injury to the Alimentary Canal.—The signs and symptoms of injury to the alimentary canal are by no means so definite at first unless stomach or intestinal contents or gas escape from the wound. In wounds of stomach and duodenum, accompanied by the escape of gas from the external wound, such gas will be odorless, or at least have no fecal odor.

In subcutaneous perforations, whether traumatic or due to ulcerative processes, we may, upon opening the abdomen, observe the escape of odorless or of stinking gas, suggesting the stomach or duodenum or the large and small intestine as a source, respectively. Evidences of peritoneal irritation, due to the escape of intestinal contents, may not appear for a number of hours. Early signs and symptoms are vomiting, sometimes of blood, rarely passage of blood *per rectum*, localized abdominal pain, tenderness, and *muscular rigidity*. During the early hours the abdominal wall is usually retracted, flat, or concave (the scaphoid abdomen), and of boardlike hardness. After six, eight, or twelve hours the signs and symptoms become those of diffuse purulent peritonitis. As a matter of experience it is observed that cases of intestinal wounds with extravasation recover in a considerable proportion of cases, if operated upon early, during the first six to eight hours; after that time the prognosis becomes much worse. When doubt exists, in a penetrating wound of the belly, as to the existence of visceral lesions, early operative exploration of the abdomen is the safest and best diagnostic measure.

Some General and Special Data.—Some general and special facts are of interest. Wounds in the epigastrium occur without wounds of the viscera more often than those in the lower part of the belly; this is especially true of stabs and punctures made with rather dull instruments; the stomach or transverse colon may be pushed aside and not perforated; the same may be true when the abdomen is penetrated by falling on a stake, an iron picket, or the like, or when the abdomen is penetrated by the horn of a bull. It should be borne in mind that the stomach or gut may be contused, and subsequently slough and perforate many days later—as late as a fortnight, for example. Such late perforations are, however, much more frequent as the result of subcutaneous injuries. Wounds of the stomach or the gut made by stabs are sometimes single, sometimes multiple. Those made by bullets are rarely single, usually multiple; four, eight, twelve, sixteen perforations are frequently observed. There are usually two openings in each wounded coil or in the stomach, as the case may be—one where the bullet entered, one where it came out. Revolver bullets, and even high-powdered rifle bullets with the full mantle and of small caliber, may, as stated under Gunshot Wounds, pass entirely through the abdomen and wound no important viscus.

The anatomical site of a stab wound and the direction of the wound canal, together with a knowledge of the length of the instrument, permits a probable diagnosis as to the organs penetrated. This is true to a much smaller extent in the case of bullet wounds, even though they have passed directly through the body. A certain number of gunshot wounds of the abdomen also pass through the pleura, lung, and diaphragm. In these cases air may enter the abdomen from the chest, and cause abdominal distention and absence of liver dullness. Stomach or intestinal contents may also pass into the pleural cavity and cause death from septic pleuritis, although the intestinal wounds have been closed and peritonitis avoided.

The gravity of the injuries produced by gunshot wounds involving both the thorax and the abdomen varies much, depending chiefly upon the character of the visceral injuries. The two following histories serve to indicate the very different results which may follow shots fired under like circumstances:

Gunshot Wounds of Pleura, Lung, Diaphragm, Intestine, and Kidney.—Case I.—G. R., a well-nourished, vigorous-looking man in the prime of life, was admitted to the New York Hospital on the afternoon of November 24, 1904. Twenty minutes before admission he had been shot in the chest with a .32 caliber revolver at close range. On admission his face was pale and anxious. Extremities cold. Pulse rapid and feeble. Rectal temperature, 99.6°. Respiration, 28, and labored. There was a bullet wound in the seventh intercostal space on the left side, in the anterior axillary line. There was no hemoptysis nor external bleeding. The abdomen was moderately distended, tympanitic, and rigid. There was absence of liver dullness. The rigidity was most marked in the left hypochondrium. The patient had vomited partly digested food. I saw the patient a few minutes after his admission, and operated upon him under ether less than an hour after the shooting. Abdomen opened along outer edge of left rectus muscle. Free blood, air, and a small amount of intestinal contents in the abdominal cavity. Upon retracting the wound edges and pushing aside the stomach a perforation could be seen in the diaphragm about four inches from the middle line, through which air and blood rushed in and out during respiration. There was a single contused wound of the transverse colon which had not opened the gut. There were two perforations in the jejunum about seven inches from its junction with the duodenum. The wounds in the gut were sutured and the abdomen washed. Efforts to close the wound in the diaphragm had to be desisted from on account of the bad condition of the patient. No active bleeding into the belly, other than from the diaphragm, was observed. Stimulation, drainage, closure of abdominal wound. Patient rallied from shock, but had a gradually increasing abdominal distention. Continued vomiting, finally, dark brown in color and with a foul odor. There was marked dyspnea and the physical signs of hemopneumothorax on the left side. On November 25th the urine contained a moderate amount of blood. His temperature and pulse gradually rose, and he died November 26th at 9.30 A.M. The autopsy showed, in addition to the injuries described, a perforating wound of the lower lobe of the left lung and a lacerated wound of the lower pole of the left kidney. There was a moderate amount of blood-stained fluid in the peritoneal cavity. The intestinal wounds were water-tight.

The second case was a young woman who, on August 19, 1905, was shot with a .32 caliber pistol in the right side of the chest at close range. She was brought to the hospital, where I saw her with Dr. P. R. Bolton, to whose service the case was admitted. The patient was pale and suffering from moderate shock. There was a bullet wound in the eighth intercostal space in the posterior axillary line on the right side of the chest. Beneath the wound in the skin there was a considerable hematoma extending over an area about two and a half inches in diameter. There was normal breathing over that side of the chest. A few fine râles could be heard posteriorly at the lower border of the lung. Aside from a moderate rise of temperature lasting for ten days and pretty severe pain referred to the right side

in the region of the wound, there were no marked symptoms of any kind. At the end of ten days the bullet was felt beneath the skin in the eighth intercostal space, between the scapular and posterior axillary line *on the left side*, and was found, upon incision, embedded in the intercostal muscles at that point. The patient made a good recovery. While the track of the bullet in this case can only be surmised, it seems possible that it penetrated the right pleura and diaphragm, the right lobe of the liver, and emerged through the diaphragm and left pleura to the point where it was found. It may, of course, have been a contour shot, but no line of pain and tenderness across the back existed to indicate such a course.

A bullet passing horizontally across the belly from flank to flank, or one passing directly backward in the center of the abdomen near the umbilicus, is more apt to cause multiple injuries than one taking an oblique course from above downward or from before backward, or one passing from before backward in the epigastrium. Bullets are much more apt to injure a number of different organs than are stab wounds. The character of the effects upon the tissues produced by different types of weapons and bullets have been sufficiently described under Gunshot Wounds. Here it may be added that the explosive effect upon hollow organs filled with fluid or semifluid material, and upon solid organs, is scarcely observed after revolver shots, such as are ordinarily encountered in the hospitals in the city of New York. The wounds are made with .22, .32, and .38 caliber pistols, rarely larger. The initial velocity is not very high.

The Chinese in the murderous affrays so common of late between their factions in this city use heavy revolvers, .44 Colt. The injuries produced, as seen in the Hudson Street Hospital, are very severe, and often fatal. If a bullet be deformed, or strike the gut obliquely, the wound may be oval or ragged and irregular in shape, and much larger than the bullet. Revolver bullets cut furrows or canals in solid organs, the edges of which are contused, sometimes fissured. Bullets which strike the intestine tangentially may cut peritoneum, or peritoneum and muscularis, without penetrating the mucosa; a shallow furrow may be created, or a flap of the outer layers of the gut may be stripped up from an area of an inch or more. If the tissues are not frayed and contused such a flap may be sutured in place with safety.

In the stomach and intestine revolver bullets, unless they strike obliquely or tangentially, make round perforations or oval holes somewhat larger than the size of the bullet. The orifice of exit is usually little if any larger than that of entrance. The edges of the openings are more or less contused. Large, soft-lead rifle bullets, express bullets (hollow-pointed), and soft-nosed jacketed bullets, from high-powdered rifles, produce very extensive lacerations of hollow organs, and churn up solid organs—liver, spleen, and kidney—into a pulp. Such wounds scarcely come under operative treatment.

Wounds of the mesentery often accompany gunshot wounds of the intestine, and are a common cause of free bleeding. They should be carefully sought for. If the mesentery is extensively wounded close to the intestinal

border, the vitality of a portion of gut may be imperiled. The appearance of the intestine is a safe guide in deciding the question for or against resection. (Further details of diagnosis will be found under Wounds of Organs.)

Subcutaneous Injuries of Abdominal Contents.—Subcutaneous injuries of the belly occur from blunt violence of all kinds—blows, falls, kicks, the tread of a horse; falls from a height against a projecting object; falls from a height upon the feet or buttocks; falls from a height upon the belly in water; run-over accidents; compression of the belly between two hard objects, railway-car buffers, etc. The injuries to the viscera are produced in various ways. A direct blow over a small area may rupture an underlying solid organ—liver, spleen, kidney; or burst a hollow organ, if distended—gall-bladder, stomach, intestine, urinary bladder. The distended stomach or urinary bladder may either of them be ruptured by moderate degrees of violence. The presence of pathological changes in the stomach, ulceration or scar tissue, increases the likelihood of rupture. The stomach usually ruptures at or near the lesser curvature, nearer the pylorus than the cardia; the rupture is commonly a longitudinal tear. In some cases direct compression of the viscera against the spine or pelvis may occur—in run-over accidents, compression by railway buffers, etc. Thus, rupture by bursting, tearing, or contusion of organs is produced—pancreas, stomach, intestine. A fractured rib may, by a continuance of the violence, wound the liver or kidney. The latter is very rare. I have seen instances of both these lesions. In falls from a height the violent commotion of the entire body may tear movable from fixed portions of the intestines—the jejunum from the duodenum, the ileum from the cecum, or tear the blood-vessels of the mesentery.

While, generally, the injuries following blows and crushes occur to the immediately underlying organs, such is not always the case; a somewhat distant organ may also be injured. In a good many cases the history of the accident, the presence of contusions or abrasions of the abdominal wall, of fractured ribs, of a fracture of the pelvis, will aid in locating the seat of the intra-abdominal injury. In many cases the injuries are multiple. One of the difficulties in the early diagnosis is that a contused portion of intestine may not slough and perforate for many days. The same is true of those cases in which the mesentery is torn away from the gut, gangrene and perforation of the latter may be long delayed.

Groups of Symptoms Observed in Subcutaneous Injuries of the Abdomen.—In general, the diagnosis of subcutaneous injuries of the abdominal contents depends upon the history of the injury and upon observation of several sets of local and general signs and symptoms. There may be present: (1) Shock; (2) symptoms of intraperitoneal hemorrhage; (3) symptoms due to rupture of the gastro-intestinal tract; (4) symptoms due to rupture of other organs. (See Liver, Spleen, etc.)

As stated, severe contusions of the abdomen are quite commonly attended by marked symptoms of shock, already described; such is not always the case.

I recall a young man who walked into the hospital with a ruptured kidney from a fall upon the loin. He concluded to walk home again, and was brought back to the hospital in a dying condition from hemorrhage. The kidney was extensively contused and ruptured. Many similar observations have been made in cases of rupture of the liver, stomach, intestine, and urinary bladder. Should the symptoms of shock be present after the accident, persist for some hours, in spite of rest and suitable treatment, and should abdominal pain, tenderness, and rigidity increase, together with the signs of progressive anemia—pallor, thirst, restlessness, a thready, rapid pulse—intra-abdominal bleeding of a serious character is present. (See also Wounds of the Abdominal Contents.)

Ruptures of the Alimentary Tract, the Stomach, or Intestine.—The symptoms and signs of rupture of the stomach or intestine in typical cases are as follows: The patient feels a sudden very severe pain at the seat of rupture. The symptoms of shock appear at once, or in a very short time. If there are other severe associated injuries he may speedily become unconscious and die. If not, he may react after a variable time. His pulse and appearance may improve. *The pain continues unabated.* There is local rigidity and tenderness of the abdominal wall. There is often hiccough. Nausea is felt, and is followed by vomiting in most cases. In some cases of rupture of the stomach there may be no vomiting. The contents of the stomach may find a ready avenue of escape into the peritoneal cavity. In ruptures of the gut vomiting is regularly present; the vomiting is repeated a number of times; the continuance of the vomiting strongly suggests injury of the alimentary tract. Following simple contusions, one or two acts of vomiting are common, but not frequently repeated vomiting. The vomited matters consist of the contents of the stomach; later, of bile-stained fluid. Blood in the vomit suggests an injury of the stomach, not necessarily a perforation. A bloody stool, rather a laceration of the mucous membrane of the bowel than a rupture. Within a few hours there are added the symptoms of peritonitis (see Wounds of Abdominal Contents); the flat or concave abdomen gradually becomes distended. The escape of gas may give rise to exaggerated tympanitic resonance around the umbilicus or to diminution or absence of liver dullness. The evidences of free fluid in the belly will not be present unless the quantity of escaped intestinal contents is very large; there will then be dullness in the flanks. It is stated that such dullness may be more marked on that side of the belly nearer to which the perforation took place. After a few hours the whole picture gradually changes to that of diffuse purulent peritonitis. In many cases the symptoms of shock simply merge in a few hours into those of the most intense peritoneal sepsis. (See Peritonitis.) In those cases complicated by rupture of solid organs or by rupture of blood-vessels the early symptoms will be rather those of shock and acute progressive anemia, together with the local signs and symptoms already described. I think it worth while to reiterate that shock may be entirely absent. Following an injury to the abdomen the patient will suffer acute abdominal pain, and will go on to develop diffuse purulent peritonitis, or in

some cases of delayed perforation, a localized peritonitis and fecal abscess. In a good many cases no absolutely certain diagnosis of rupture of the gut can be made during the early hours following the injury. In others, although reasonably sure that a rupture exists, we are unable to tell what portion of the intestinal tract is injured. In the treatment of these cases we should remember that if an operation is to be done at all, the sooner it is done the better the chances of recovery. The surgeon will not, of course, open the belly of an actually moribund individual. In other cases less desperate he will delay the operation, and seek by warmth and other stimulating measures to get the patient into better condition and to make a definite diagnosis. Some of these cases will be saved even by a delayed operation. In still other cases the symptoms of perforation will not appear for many hours, or, in cases of delayed perforation, not for many days. The symptoms of shock will pass away, and the patient enjoy a longer or shorter period of relative comfort, to be followed, suddenly or gradually, by symptoms which vary according to the following local conditions: The rupture may be closed by prolapsed mucous membrane, notably if the organ is empty. Leakage may finally take place, to be followed by progressive fibrino-purulent peritonitis, or adhesions may form, closing off the site of the perforation. Several results are then possible; in rare cases no leakage will occur, the perforation will heal. In others, the adhesions will break down with the production of a progressive peritonitis or of a localized peritonitis with abscess; and these conditions will give their characteristic signs and symptoms; such an abscess may break into the intestine, perforate the diaphragm into the pleura, or even the abdominal wall. (See Peritonitis.) In the cases of delayed perforation from contusion of the wall of the gut, sloughing may finally take place and peritonitis develop at the end of a week or ten days. If the original perforation be small and the leakage slow, and, notably, if it takes place in a pocket of peritoneum, the bottom of the pelvis, the lesser peritoneal sac, and if the bacteria be not very virulent and the amount of intestinal contents extruded small, there will follow the original injury in twelve to twenty-four hours the signs and symptoms of a localized peritonitis, gradually or slowly developing, usually ending in the formation of an abscess. Lastly, as stated under wounds of the viscera, if the rupture occurs in a part of the gut not covered by peritoneum—posterior surface of ascending colon, descending colon, or posterior surface of descending portion of duodenum—a localized abscess will form outside the peritoneal cavity, or a septic phlegmonous inflammation, with the production of definite signs and symptoms. It has been my own practice in subcutaneous injuries of the abdomen, especially in those cases showing signs of progressive anemia, to operate at once in spite of pretty severe symptoms of shock; a number of these cases with rupture of solid organs—liver, kidney, spleen—have recovered. Ether *acts as a powerful heart stimulant*, and under the anesthetic the symptoms of shock will often diminish or disappear; other stimulants, including saline infusions, may be given on the operating table, the latter *after any source of active bleeding has*

been controlled. A number of cases have died, but not, in my judgment, because of the operation. In cases where the diagnosis remains uncertain the patient should be watched with care and treated, as far as rest, diet, etc., are concerned, as though a perforation existed; such cases cannot be considered out of danger for a fortnight. *The use of morphin should as far as may be omitted.* The development of the signs of peritonitis are an indication for immediate operation.

CHAPTER XXV

INJURIES OF SPECIAL ABDOMINAL ORGANS

The Stomach.—Aside from the history of the accident, the situation of the contusion or wound and the signs and symptoms mentioned in the preceding chapter, it is difficult to give any certain differential signs whereby we may conclude that the stomach alone is injured. Often we are obliged to content ourselves with the diagnosis, perforation, or rupture of some part of the alimentary tract, until the abdomen is explored.

Injuries of the Duodenum.—The duodenum is rather rarely injured as the result of stab and gunshot wounds. Rather often as the result of blunt violence; since, being fixed and lying partly against the spine, it cannot slip away from a compressing force as readily as the more movable portions of the intestine. In a number of cases the rupture has been complete, the duodenum being torn completely across at its junction with the pylorus. If the rupture occurs in the intraperitoneal portion of the gut, diffuse peritonitis is the result. If in the retroperitoneal portion, a retroperitoneal phlegmonous process or an abscess with or without a secondary peritonitis. Intraperitoneal rupture can scarcely be differentiated from rupture of the stomach. The pain is referred rather to the right of the middle line. Vomiting of the contents of the stomach or of blood occur in about half the cases. In these cases which do not involve the peritoneum there will be a fixed, continuous, deep pain in the epigastrium, localized tenderness and rigidity, pronounced septic symptoms, sometimes the formation of a palpable mass as the abscess increases in size.

Injuries of the Jejunum and Ileum.—Injuries of the jejunum and ileum are frequent both as the result of open wounds and contusions of the abdomen. Open wounds, especially gunshot wounds, usually cause multiple perforations. As already indicated, complete rupture may take place as the result of blunt violence, notably at the flexura duodeno-jejunalis and at the ileo-colic junction. I have seen several complete ruptures in other situations from kicks and blows upon the abdomen. In several cases the contusion of the abdomen was not followed by very marked symptoms at once. Sloughing and perforation of the contused gut took place only after several days. The peritonitis following wounds and ruptures of the small intestine is of a severe type. Two cases treated by me in the Roosevelt Hospital may serve as illustrations:

Case I.—A man of fifty-five was kicked by another in the lower part of the belly. He had a severe pain in the abdomen, vomited, and felt weak, but was able to walk home, where he remained in bed. During the next forty-eight hours he suffered but little. His general condition remained good. On the third day he was suddenly seized with violent pain in the abdomen, repeated vomiting, and prostration. He remained at home thirty-six hours longer, and was brought to the hospital in the ambulance on the morning of the fifth day after the injury. At that time he was severely ill, countenance pinched, pulse 150 and thready, temperature 102° F., respiration 36, cerebration clear. Abdomen distended, tender, and rigid, everywhere tympanitic. The liver dullness absent. There was a contusion of the abdominal wall to the left of the umbilicus. Immediate abdominal incision in the middle line above and below umbilicus, under ether anesthesia. Upon opening the peritoneum a gush of foul-smelling gas, pus, and intestinal contents escaped under tension. There was a rupture of the ileum near the jejunum, involving one half the circumference of the gut. The wall of the intestine was contused and its vitality impaired over half its circumference for a distance of three quarters of an inch on either side of the perforation. Resection of contused portion of gut. End-to-end anastomosis by suture. Irrigation of belly. Peritoneal cavity contained a large amount of pus, fibrin, and intestinal contents. There were no limiting adhesions; the process was diffuse. The intestine, except in the vicinity of the rupture, was distended and evidently paralyzed. No movement of the bowels had occurred since the injury. Partial closure of abdominal wound. Drainage. Death the following day without improvement of symptoms.

Case II.—A young man was kicked in the center of the abdomen by a horse. He fell, vomited, and was brought to the hospital in a state of profound shock. He complained of intense pain in the lower half of the belly. The abdomen was concave, rigid, and tender, notably over the lower half. The condition of the patient was so bad that rest and stimulating measures were used for five hours before his belly was opened. Median incision under ether. Abdomen contained a good deal of intestinal contents and some gas. There was a complete rupture of the ileum near the cecum, extending a short distance into the mesentery; bleeding had not been active. Union of the divided ends of ileum, after trimming, with the Murphy button. Irrigation of abdomen and closure of wound. Death six hours later, with continuance of symptoms of shock. No autopsy.

Case III.—A young man was thrown from a bicycle, striking his umbilical region against a post. Severe pain and abdominal rigidity with marked shock. Operation the following day. Three ruptures of small intestine, jejunum, and ileum; one of them a complete severance of the gut. Diffuse purulent peritonitis. Exitus letalis in forty-eight hours.

Wounds and Ruptures of the Mesentery.—Wounds and ruptures of the mesentery frequently complicate injuries of the small gut. The signs and symptoms of injuries of the mesentery alone are those of intra-abdominal bleeding. The following case history illustrates the symptoms and course of a gunshot wound of the stomach and small intestine and mesentery:

Bullet Wound of the Stomach and Small Intestine.—A man, aged thirty-five years, was admitted to Roosevelt Hospital on the afternoon of April 2, 1899, at 5.40 P.M., with the history that one hour before he had been approached by another man who pushed a .38 caliber revolver against the front of his abdomen and fired the contents of the weapon through his body.

The wounded man preserved sufficient strength to get into a cab, which happened to be near, and was driven at once to Roosevelt Hospital. Upon admission the patient was seen to be a man in robust health, and evidently in the most perfect physical condition. He was fully clad, and wore an overcoat, through the front of which over the abdomen was a hole burned an inch or more in diameter, with corresponding perforations in his coat, waistcoat, shirt, and undershirt. When undressed and placed in bed, a .38 caliber, conical, lead bullet dropped out of his clothing. Considerable hemorrhage had occurred from a wound of exit in his back. He appeared to be suffering from shock and hemorrhage; he was pale. His temperature was subnormal, 97.2° F.; pulse, 88, soft and compressible; respirations, 22.

He complained of intense distress in the abdomen and begged for relief. Examination of the abdominal wall in front showed a powder burn and a ragged perforation in the skin at its center, situated three inches below the ensiform cartilage and an inch to the right of the median line. The powder burn was quite superficial and about an inch in diameter; this wound did not bleed.

Upon examining the patient's back the wound of exit was seen to the left of the median line, and four inches from it, just above the posterior superior iliac spine.

The wound of exit was small, and when examined had ceased to bleed. At 6.25 P.M., about an hour and forty-five minutes after the receipt of the injury, under ether, an incision was made in the median line of the abdomen, from a point two inches below the ensiform cartilage, downward to an inch and a half below the navel. Upon opening the abdominal cavity a large amount of fluid blood escaped. The stomach presented in the wound. A perforation was found in its anterior wall near the lesser curvature and about two inches removed from the pylorus. An artery of some size at the edge of this perforation was bleeding freely, and was ligated. The muscular coat was denuded of peritoneum around the borders of this hole, forming a solution of continuity in the latter membrane of the diameter of an inch. The mucous membrane showed a ragged everted border, and from the cavity of the stomach bile-stained stomach contents and gas were freely escaping. This perforation was closed by two purse-string sutures, one outside the other, and the closure reënforced by five mattress stitches, all of catgut. The gastrocolic omentum was then torn through, the hand inserted into the lesser peritoneal cavity, the stomach dragged out through the rent, and its posterior surface examined.

A perforation similar in character to that upon the anterior surface was found about an inch and a half from the greater curvature, and much farther

to the left than the anterior perforation. From it also stomach contents were escaping. It was closed by suture in the same manner as the anterior perforation, but with rather more difficulty. The rent in the gastrocolic omentum was held widely open, and the lesser peritoneal cavity repeatedly flushed out with hot sterile salt solution; afterwards it was wiped dry with large pads of sterile gauze. Search was then made for intestinal perforation; it soon became evident that the question of hemorrhage required immediate attention, the manipulations having evidently caused an increased amount of bleeding of the most serious character.

At this time the patient's color, breathing, and pulse underwent a sudden change for the worse, and blood welled up from among the coils of intestines in a manner which rendered a decision as to its source somewhat difficult. After a few moment's search a jagged tear was found in the mesentery of the first coil of the jejunum, about five inches below the insertion of Treitz's ligament, and close to the border of the gut. Several vessels in the borders of this wound of the mesentery were bleeding rapidly. The contused edges of this wound rendered the use of ordinary hemostatic forceps difficult, and the edges of the tear were therefore surrounded or included in three catgut ligatures passed by means of an aneurism needle.

Opposite to this wound of the mesentery the jejunum was perforated, and from the hole intestinal contents were escaping. The long axis of the perforation lay transversely to the caliber of the gut.

The wound was closed by a row of Lembert stitches inserted in a line at right angles to the axis of the intestine. An inch and a half from this perforation the intestine had been scored by the bullet for a distance of two inches and a half, in such a manner as to split the peritoneal covering of the gut, laying bare the muscular coat over a considerable area. The edges of the torn peritoneum were stitched together, thus closing the rent. Fine catgut was used on all the sutures.

The injury to the mesentery lying close to the intestine and immediately opposite to the site of the intestinal perforation would, in the then opinion of the writer, have demanded a resection of that portion of the bowel, but, in spite of stimulation of the most active kind, the patient's condition at this time forbade any further operative measures. He was pulseless with dilated pupils, the tension of the eyeballs reduced, and the breathing shallow, infrequent, and gasping.

While the latter part of the operation was going on preparations were made for intravenous infusion of salt solution. It required some persuasion on my part to induce the house surgeon to make this infusion, because, he said, the man did not bleed; his veins were empty; he had no pulse; he had ceased to breathe, and was therefore dead. The infusion was commenced, and after some 400 or 500 c.c. of hot water and salt had been added to the patient's circulation, signs of returning vitality were evident. The infusion was continued until 1,800 c.c. had been given at a temperature of 118° F.

When the infusion was finished the patient was breathing regularly, he had a pulse of 120, and of fair quality, and his color was much improved. While the infusion was being administered the abdominal cavity was repeatedly flushed with hot sterile salt solution, all fluid blood and clots were removed, and the cavity wiped dry with sterile pads. A strand of gauze was carried down to the site of perforation in the jejunum, and brought out of the upper angle of the wound.

While flushing the abdomen a wide rent was found in the inner edge of the descending mesocolon, through which three fingers could be introduced through the muscles of the back to the wound of exit in the skin. (This wound did not bleed, and was merely washed out and wiped dry with gauze.) The wound in the transverse mesocolon, through which the bullet passed after leaving the stomach and before entering the jejunum, did not bleed, and therefore its exact position was not noted. The wound was closed by layers with buried catgut and superficial silk stitches. The time from the beginning of the anesthesia until the patient was removed from the operating table was an hour and ten minutes. Following the operation the patient was stimulated with strychnin and digitalin, one thirtieth and one fiftieth of a grain respectively, every two hours. He received enemata of coffee and whisky, and to relieve thirst, and to replace as far as possible the loss of fluids, he was given enemata of normal salt solution, a quart at a time, every six hours. For the first four days he received nothing by mouth but small doses of hot water.

On the day following the operation his temperature rose to 101.4° F. By the end of the second day his pulse had fallen to 80, and was of good quality.

Soon after the operation the patient began to suffer from severe and continuous hiccoughs, which could only be controlled for a few hours at a time by full doses of morphin; he vomited at intervals during the first five days considerable quantities of dark chocolate-colored fluid. This vomiting was treated upon the fourth day and thereafter by frequent washing out of the stomach with warm water, which rendered the vomiting less distressing and diminished the severity of the hiccoughs. Upon the fourth day the gauze drainage was removed from the abdomen and appeared clean. The external wound remained aseptic.

Upon the fifth day the amount of vomiting appeared to be increasing; the patient was suffering from severe abdominal pain and hiccoughs; his temperature had risen from normal to 100.6° F.; his pulse had become rapid and more feeble. Owing to these symptoms, which seemed to show that there was a constant regurgitation of intestinal contents into the stomach, and owing to the supposed feeble nutrition of the gut at the site of the perforation in the jejunum, on account of its diminished blood supply, it was feared that the intestine might have undergone necrosis at this point, and for these reasons the patient was again etherized upon the evening of the fifth day, the upper part of the abdominal wound was opened, and the jejunum and mesentery at

the point of injury were carefully inspected. No adhesions except of the slightest character were found. The belly was dry, the uppermost coils of small intestine appeared flabby, slightly reddened, but not distended.

The site of the wound of the mesentery could only be distinguished as a moderately reddened depression, close to the border of the gut. At the point of perforation in the gut itself could be seen merely a very slight reddened projection, to which a minute portion of catgut adhered. The stomach was not inspected. The wound was closed with sutures.

Upon the day following this operation the patient's temperature rose to 102.4° F. He continued to vomit and to hiccough. After washing of the stomach he was fed with beef juice by the mouth. In the afternoon of that day he was given calomel in divided doses, which was effective on the day following, after which his general condition was greatly improved.

His temperature and pulse soon fell to normal; he ceased to vomit; the hiccoughs persisted, but grew less intense and with remissions. Although the wound in the abdominal wall remained entirely aseptic, yet the superficial portion of the wound at its upper part failed to unite completely by primary union after it had been resutured, necessitating the use of straps and stimulating applications. The patient was allowed to get up out of bed upon the nineteenth day, since when his convalescence had been rapid, except for occasional attacks of indigestion, brought about by the incautious use of food. He rapidly regained his physical strength, and thirty-eight days after the injury he was able to eat heartily and to walk several miles without undue fatigue.

An unusual and interesting observation was made some years ago by Dr. Charles McBurney in the Roosevelt Hospital. A negro woman was shot in the epigastrium with a .32 caliber pistol. The bullet entered in the middle line two inches below the ensiform cartilage. There was vomiting of blood, but no symptoms of shock. Upon opening the belly a hole was found in what appeared to be the anterior wall of the stomach, since blood and stomach contents escaped. The peritoneal cavity seemed to be obliterated by an old chronic peritonitis with adhesions. The stomach could not be freed from surrounding structures without undue violence. The wound in the stomach was closed with sutures, as well as the external wound in part. The patient made a rapid recovery without further serious symptoms.

Wounds and Ruptures of the Large Intestine.—Wounds and ruptures of the large intestine differ but slightly in their nature, causation, and results from those of the smaller gut. The bacteria of the colon are abundant and virulent. The contents of this portion of the gut are often solid, its peristaltic motions are slower and less active. Thus, sometimes, leakage is slow or delayed. A portion of the colon is extraperitoneal, and, though relatively infrequent, wounds and ruptures may result in an extraperitoneal extravasation and the production of an abscess containing fecal matter and gas, or a septic and necrotic infiltration of the tissues of the loin. Such extravasation may be quite slow, and the local signs and symptoms may not appear for several days.

The two following cases illustrate an intraperitoneal and extraperitoneal injury of the colon respectively:

Case I.—A woman was stabbed with a dagger in the abdomen and brought immediately to the New York Hospital and entered my service. A linear wound three fourths of an inch long was found in the left side of the abdomen, one inch below the costal border in the anterior axillary line. There was no shock. Abdominal pain was complained of in the region of the wound. Temperature and pulse normal. Operation three hours after the injury. Wound enlarged and found to penetrate the belly. Incision parallel to the ribs. There were three incised wounds of the splenic flexure of the colon, each about one third to one half inch in length. The orifices were found plugged by prolapsed mucous membrane. No leakage had occurred. Suture with fine catgut; abdominal wound closed. Recovery uneventful.

Case II.—In 1886 a woman was shot from behind with a .38 caliber pistol in the right loin, and brought to Bellevue Hospital. Shock was moderate. There was a wound midway between the last rib and the crest of the ileum in line with the angle of the scapula. The wound was round, 5 mm. in diameter, the edges contused. Bleeding was slight. There was no wound of exit. The symptoms of shock passed away during the first day. No symptoms of peritoneal infection occurred. There was no vomiting. At the end of forty-eight hours the patient complained of pain in the loin, and developed an irregular febrile movement. The external wound was covered with a dry scab. On the fourth day a tender, painful mass of infiltration could be felt deep in the loin beneath the wound. The patient felt ill. Incision evacuated pus, gas, and fecal matter. The wound was drained with a large tube. The patient's condition was improved by the operation. Pain and fever subsided. Fecal matter continued to be discharged from the wound. At no time was blood observed in the stools. On the seventh day the patient began to show signs and symptoms of gradually increasing sepsis. The wound in the loin was enlarged. An extensive putrid, necrotic, and purulent inflammation was found in the intermuscular planes and retroperitoneal loose connective tissue. There was a ragged hole in the posterior wall of the ascending colon an inch in diameter. The patient succumbed to septic poisoning on the fourteenth day after the shooting. No autopsy.

Wounds of the Omentum.—Wounds and tears of the omentum rarely give rise to serious symptoms if uncomplicated; exceptions occur (see case related). As stated, the great omentum frequently protrudes even through very small wounds of the abdominal wall; its appearance is a positive and valuable sign of penetration.

Injuries of the Stomach from Within.—The stomach may be injured by swallowing caustic fluids, acids, and alkalies—nitric acid, sulphuric, hydrochloric, oxalic, and carbolic acids. Potassium, sodium, and ammonium hydrates; other substances, notably corrosive sublimate and arsenious acid, may cause a very intense inflammation of the stomach. When true caustics are swallowed, the mouth, pharynx, and esophagus are nearly always cauterized.

The lesser curvature and the pylorus are the parts of the stomach affected. The intensity of the effect depends largely upon the concentration of the caustic liquid, and varies from the production of hyperemia, catarrhal inflammation, destruction of the mucous membrane, to perforation of the stomach. The effects of caustics upon mucous membranes have been described under Burns. Here it may be said of such injuries of the stomach:

The eschars produced by sulphuric acid are black.

The so-called sulphate of indigo, a solution of indigo and sulphuric acid, produces like effects. The tissues are stained dark blue. Perforation is not uncommon.

Nitric acid produces yellow eschars. Perforation is rare.

Hydrochloric acid produces eschars, at first white, later discolored. A false membrane forms over the cauterized areas. Perforation is rare.

Oxalic acid: The mucous membrane of the stomach may be softened and shreddy, looking as though boiled in water. In other cases swollen, congested, or gangrenous. Perforation is rare.

Caustic alkalies, sodium and potassium hydrate: The mucous membrane of the stomach is softened, swollen, congested, and inflamed, or may be tough and leathery, or peeled off, or blackened.

Corrosive sublimate produces an intense inflammation of the mucous membrane of the stomach. Grayish-white areas of false membrane may be formed; ecchymotic and gangrenous areas may be present. Perforation is very rare.

Arsenious acid and its compounds may cause diffuse or localized inflammation of the stomach. There may be patches of false membrane containing particles of the poison; ecchymoses are common. Gangrene and perforation are rare. Acute inflammation of the entire gastro-intestinal tract is one of the specific effects of arsenic, irrespective of the method of administration.

Carbolic acid produces white sloughs; later these may turn black or brown; the odor is usually characteristic. (Delafield and Prudden.)

The symptoms produced by swallowing caustics are, in addition to those referable to the mouth, pharynx, and gullet, a violent pain in the upper part of the abdomen, vomiting of the contents of the stomach. The character of the vomited material may indicate the nature of the caustic; in severe cases vomiting of blood or of fragments of sloughs. A good many of the cases exhibit the symptoms of profound shock, from which they do not recover. Others die of the specific effects of the poison; still others from phlegmonous inflammation of the wall of the stomach; others from perforation and the symptoms of diffuse peritonitis. The condition is interesting from a surgical point of view, chiefly because among those who survive, cicatricial contraction may produce strictures of the gullet and of the pylorus; sometimes hour-glass deformity of the stomach, or chronic ulcers develop at a later period, and give rise to obstructive and other symptoms.

Foreign Bodies in the Stomach.—Foreign bodies gain entrance to the stomach for the most part through the mouth. Foreign bodies are swallowed by design by lunatics, hysterical individuals, criminals, professional jugglers, and

sword swallowers; sometimes by children. They are swallowed by accident with food, and by children and others who have the dangerous habit of carrying foreign bodies in their mouths. (See Injuries of and Foreign Bodies in the Esophagus.) The variety of foreign bodies which may reach the stomach is large; among them may be mentioned needles, pins, coins, buttons, knives, forks, spoons, pieces of meat bone, fish bones, beads, sharp pieces of glass and metal nails, screws, false teeth and tooth plates, natural teeth and fragments of teeth, hairpins, stones, wooden articles of various kinds, watches, pipe-stems and mouthpieces, of clay, rubber, or amber, sword blades, portions of stomach tubes or esophageal bougies. Rarely among human beings, very commonly among plant-eating animals, hair and vegetable fibers swallowed, remain in the stomach and, becoming matted together, form a ball of considerable size, to which gradually additions are made as more hair or vegetable fiber is swallowed, until a large mass is formed, giving the signs and symptoms of tumor of the stomach. A few such cases are observed from time to time among human beings as the result of a habit of chewing and swallowing hair, for the most part among young girls whose hair is arranged in a queue, the end of which is chewed, or among hysterical women who swallow hair. The masses composed of vegetable fiber have arisen from a diet containing large amounts of coarse vegetable fiber. Foreign bodies occasionally reach the stomach in other ways. Through the abdominal wall, as the result of stab or gunshot wounds, a portion of a knife-blade or a bullet may remain in the stomach; long needles and similar articles may do the same. Gall-stones have been found in the stomach, having ulcerated through the gall-bladder and pylorus, or reached the stomach from the duodenum by ulceration. A Murphy button sometimes passes into the stomach after the operation of gastro-enterostomy. Lumbricoid worms sometimes crawl into the stomach from the small gut. The size of foreign bodies which may pass the gullet and reach the stomach is remarkable not only in the case of professional swallowers, but also among ordinary individuals. Sets of false teeth, large pieces of metal, large coins, knives, forks, spoons, and other large objects accidentally swallowed often reach the stomach without difficulty. The symptoms produced by foreign bodies in the stomach are varied. If the body is small or smooth or without sharp angles, it may remain in the stomach indefinitely and produce no symptoms. If sharp-pointed, pointed at both ends, jagged, angular, or hooked, it may produce functional disturbances or pressure ulceration, or finally perforation and peritonitis; either diffuse peritonitis or a localized abscess. Such an abscess may break into some other part of the intestinal tract, or outwardly through the abdominal wall, leaving a fistula behind or closing on removal of the foreign body. Small sharp bodies, like needles and pins, may perforate suddenly with serious results or leave the stomach and appear beneath the skin of the abdominal wall without evidences of inflammation. (See case quoted in another chapter of a lunatic who swallowed many needles.) A number of similar cases are on record. The functional disturbances may be loss of appetite,

colicky pain, distress after eating, a sense of heaviness, nausea, etc. The symptoms of ulceration, perigastritis, abscess, peritonitis, etc., are described under Peritonitis. If the foreign body becomes impacted in the pylorus, it may produce the symptoms of obstruction. The records of operations and autopsies on the bodies of professional swallowers show that an extraordinary number and weight of foreign bodies of the most varied size, shape, and character may remain in the stomach without producing serious symptoms. (See Gastric Tetany.) In most instances when the body is not too large, and is not jagged, angular, hooked, or sharp at both ends, or is not very sharp (fragments of glass, for example), it will leave the stomach, and finally be passed *per rectum*. If it possesses the undesirable qualities mentioned, it may remain in the stomach, there to cause trouble or pass the pylorus and cause perforation, etc., of some portion of the gut. The time during which a foreign body may remain in the stomach before it passes the pylorus, and is finally evacuated *per rectum*, varies from a few days to many months. Sometimes foreign bodies in the stomach are vomited after a long interval. While waiting for a foreign body to leave the stomach, the diet should be starchy; neither purgatives nor opiates should be given. When the foreign body remaining in the stomach is of considerable size and weight, it may be removed by gastrotomy without serious risk. Recently I removed a fifty-cent silver piece from the stomach of a boy aged ten. Repeated X-ray examinations showed that the coin remained in the cardiac end of the stomach. Upon opening the stomach it was easily removed with the forefinger (see illustration, Fig. 257). The diagnosis of foreign bodies in the stomach is often highly important; at times easy, at times difficult. The history may be plain or doubtful, the body may have reached the stomach after unsuccessful efforts to extract it from the esophagus. From children, hysterical people, and fools it may be impossible to obtain a reliable history. Hypochondriacal lunatics sometimes believe that they have swallowed foreign bodies, usually small animals, who continue to inhabit their stomachs. These delusions may have as a basis gastric dyspepsia, etc. I saw an elderly lady who stated that a lizard inhabited her stomach, and that at the word of command it would crawl up on the back of her tongue and remove a piece of orange peel. Patients

Fig. 257. — Fifty-cent Silver Piece in the Cardiac Portion of the Stomach Removed by Gastrostomy. (Author's collection.)

who have swallowed a foreign body often become depressed and neurasthenic. If the foreign body is known to have passed into the stomach, it may in some cases be seen in the stomach through the esophagoscope (von Mikulicz). If it be metallic or of such material as to cast an X-ray shadow, it may be located accurately by a radiograph, and its subsequent progress through the alimentary tract watched. The stools should regularly be inspected. If the foreign body remains in the stomach and produces inflammation, ulceration, or perforation, it will produce definite symptoms of gastric ulcer, or of localized or diffuse peritonitis. If it becomes attached to or wedged against the anterior wall of the stomach, and is of considerable size, it may be palpable through the abdominal wall. The diagnosis of hair and vegetable-fiber accumulations in the stomach has rarely been made before operation. The symptoms may be pain, functional disturbances of the stomach, or none. The physical signs on palpation are those of a movable tumor of the stomach, which disappears upon the patient assuming certain positions. The mass may be rounded, or if large may represent in shape a cast of the stomach. Such masses have usually been mistaken for a movable kidney, a spleen, or a tumor of the stomach.

Foreign Bodies in the Intestine Below the Stomach.—Those foreign bodies which succeed in passing the pylorus usually traverse the remainder of the alimentary canal without difficulty. There are, however, exceptions to this rule, to be noted below. Gall-stones may enter the intestine by ulceration from the gall-bladder, and if very large may cause obstructive symptoms. Such stones may by irritation produce a local spasm of the muscular wall of the gut, so that the stone is tightly grasped by the intestine, and thus produces intestinal obstruction, although the caliber of the canal may be abundantly large to permit its passage. Instruments, drainage-tubes, and packings left in the abdomen after surgical operations may ulcerate into the gut. It is also possible that needles, pins, bullets, knife blades, etc., introduced into the abdomen from without should enter the gut in the same way. Foreign bodies may also originate in the intestine itself. Intestinal concretions frequently form in the large intestine, very frequently in the vermiform appendix; very rarely in the small gut. Such concretions may be true enteroliths, consisting of earthy salts, or hardened masses of fecal matter embedded in mucus. These concretions rarely reach a large size. Aggregations of vegetable fibers and of fruit seeds occasionally form in the large intestine. In rare cases, tangled masses of worms, Ascaris lumbricoides (roundworms), as well as Oxyuris vermicularis (pinworms), in the intestines of children may give rise to obstructive symptoms. I knew of a case in which a balled-up mass of pinworms became impacted in the ileo-cecal valve of a child, caused acute intestinal obstruction, and was removed by operation. Large masses of fecal matter may collect in the large gut of people of constipated habits, old people, paralytics, and those who suffer from injuries and diseases of the spinal cord, as well as above cicatricial or other forms of chronic obstruction of the bowel. Such masses may finally become of stony hardness. Foreign bodies swallowed, if sharp, angular, or

hooked, may, though they pass the stomach, finally lodge and remain in some lower portion of the gut. Dr. Eugene Hodenpyl informed me recently that he saw total obstruction of the small intestine produced by half a dried peach. Presumably the dried and shriveled mass was swallowed whole, and had soon passed the pylorus, entirely undigested, imbibing water, and swelling in the small intestine to such a size that it completely and firmly occluded it. The body was impacted a foot from the ileo-cecal junction in the ileum. The element of muscular spasm from irritation may have been present in this case. Bodies of considerable size tend to lodge in the flexures of the duodenum and colon, at the ileo-cecal valve, in the cecum, and just above the anal sphincters. Foreign bodies of small size—bird shot, pins, grape seeds, etc.—may enter and remain in the vermiform appendix. Such an occurrence is conceivably a cause of appendicitis. I recall two cases: in one of them a bird shot was in the appendix, in the other a pin. There was no reason to believe that the foreign bodies were the cause of the appendicitis in either case. Murphy buttons do not cause obstruction; the buttons are perforated with numerous holes; the contents of the small gut are fluid. The colon is large enough for the button to pass.

Diagnosis.—The diagnosis of foreign bodies in the intestine may be simple or impossible. If it is known that the patient has swallowed a foreign body which has not passed, if an abdominal operation has been performed, or if there is a definite history of gall-stones, the diagnosis may be clear: if no such history exists, no diagnosis will be made until an operation is done for intestinal obstruction, or for localized or diffuse peritonitis from ulceration and perforation, when the body may be discovered in the gut, or in an abscess. The obstructive symptoms caused by foreign bodies vary from the slightest grades of stenosis to complete intestinal obstruction. If a stricture of the bowel exists, simple or malignant, a small foreign body may cause complete obstruction. If a foreign body is large and hard and the abdominal wall thin, it may be palpable through the abdominal wall. Large masses of hardened fecal matter in the colon give the signs of a tumor connected with the colon often of considerable size; they may remain *in situ* for weeks. They are accompanied by a history of constipation of the bowels, sometimes followed by diarrhea. They very rarely cause the symptoms of intestinal obstruction. They may often be recognized from the history of the case, from their situation in the colon, and from the fact that the mass can be indented with the fingers and retain its shape like putty. The finally efficient action of purgatives and of carefully given high enemata usually establishes the diagnosis. The symptoms produced by foreign bodies which cause ulceration and final perforation may be slight or absent until a localized or general peritonitis occurs or may be preceded by the symptoms of obstruction of the bowel more or less marked. Metallic foreign bodies may, as already stated, be located by means of a radiograph. I recall two cases of foreign bodies in the gut requiring operative removal. The one was an artery clamp left by a surgeon in the abdomen. The patient con-

tinued to complain of abdominal pain and disturbances of digestion. At the end of a year or more a second operation was done. The clamp was found and removed. The handles of the clamp had ulcerated through into the small gut and were much eroded; the rest of the instrument, including the jaws, lay outside the intestine embedded in adhesions.

The second case I saw in the service of Dr. Robert Abbe at Roosevelt Hospital. An old woman entered the hospital with a large inflammatory mass in her right iliac fossa; incision opened an abscess communicating with the cecum. A chicken bone of considerable length lay partly in the abscess, partly in the cecum.

I recently operated upon an old lady who had had, when I first saw her, symptoms of intestinal obstruction from obturation for five days. I removed a large gall-stone from the jejunum which completely occluded the gut. The operation might have been successful, but the patient had been left too long unrelieved, and died from shock.

Gastric Fistula.—A gastric fistula may open through the abdominal wall. Rarely a fistulous communication may exist between stomach and the transverse colon or duodenum, rarely the ileum. If into the duodenum, no symptoms referable to the fistula are likely to develop. If into the ileum, the nutrition of the individual may suffer. A fistulous communication between the stomach and the kidney was reported as a single undoubted case, verified at autopsy by Henry Morris. External gastric fistulæ, except such as are made intentionally or follow accidentally a surgical operation upon the stomach, are rare. Wounds and perforations of the stomach are much more apt to be followed by generalized or local peritonitis. Still, such fistulæ do occasionally occur as the result of stab and gunshot wounds of the stomach; perforations of the stomach from within from gastric ulcer or foreign bodies. The external fistulæ are nearly always of the anterior wall of the stomach in the epigastrium or near the costal border upon the left side. Rare fistulæ opening through the pleura and chest have been reported. The mucous membrane of the stomach may be adherent to the skin, or there may be a canal of greater or less length, or a cavity of some size between the skin and the stomach. The symptoms of gastric fistula consist of the escape of stomach contents, gastric juice, and mucus through the fistula. According to the size of the opening, the discharge may be large or small. Usually the material is acid in reaction. If a cavity exists between the skin and the stomach, and the stomach orifice is small, the discharge may be mixed with pus and mucus, and be neutral, even alkaline in reaction. Usually the skin becomes irritated around the fistulous opening. Eczema develops. The gastric juice may digest the skin, causing painful ulceration. Usually the diagnosis of external gastric fistula is very simple. If the orifice is small, it may be difficult to tell whether the fistula communicates with the stomach or the duodenum. Above the orifice of the ductus communis in the duodenum, the contents of the bowel cannot be distinguished from that of the stomach. In the latter case colored fluids swal-

lowed (methylene blue) will usually appear very soon in the fistula; in the former, only after an interval. If gastric fistula is large, so that the food is not properly retained in the stomach, the general nutrition will suffer; otherwise not. From very large openings death may ensue from inanition. The ordinary operative fistulæ of the stomach close of themselves if let alone. Pathological ones, if of considerable size, and especially if the mucous membrane of the stomach becomes adherent to the skin, do not. In cases of gastric fistula into the transverse colon, if the orifice is of some size, nutrition may suffer severely. Undigested food, milk, or colored fluids will appear speedily in the stools after swallowing them. There may be actual fecal vomiting from the entrance of scybalous masses into the stomach from the colon. Air or fluids may usually be injected from the rectum into the stomach, and recognized by percussion or the use of the stomach-tube. The general nutrition suffers severely.

Intestinal Fistulæ.—Fistulæ of the intestine below the stomach are much more frequent than the gastric variety. They may open upon the skin or internally into other coils of intestine or into adjacent hollow organs.

External Fistulæ.—Intestinal fistulæ opening upon the skin occur from a variety of causes. They may be made by surgeons for therapeutic purposes. In order to feed the individual—jejunostomy in certain cases of cancer of the stomach, etc. In order to afford escape to intestinal contents, either temporarily or permanently, in cases of acute and chronic intestinal obstruction, or paralysis of the gut, or for the purpose of applying local treatment to the interior of the gut in cases of disease (appendicostomy in chronic colitis). They may arise accidentally from incised stab or gunshot wounds of the abdomen when the intestine becomes prolapsed or adherent at the point of injury to the edges of the wound, or when a localized peritonitis and abscess is formed as the result of open wounds or subcutaneous ruptures of the gut which perforates the abdominal wall or is incised. As already alluded to, an extraperitoneal fistula is possible in certain situations. Further, as the result of operations upon the intestinal tract when sutures placed in the gut fail to hold, or when the sutured or ligated structures become necrotic (appendical stumps), and that whether the abdominal wound is closed or not. Further, from accidental unrecognized injury of the normal or diseased intestine during abdominal operations. Fistulæ also result from a great variety of intra-abdominal processes—foreign bodies, which perforate the gut, ulcerative and gangrenous processes of the intestine (appendicitis, typhoid fever); such fistulæ are commonly preceded by a localized peritonitis and abscess which perforates outwardly; malignant tumors of the gut which invade the abdominal wall and ulcerate; tuberculosis and actinomycosis of the intestine. Similar processes originating in the peritoneum or in the abdominal wall may at once invade the belly wall and the gut, may break down, and result in fistula. Unoperated strangulated herniæ which fail to kill by obstruction or peritonitis may result in an intestinal fistula. The gut becomes gangrenous, is perforated, its contents escape into the surrounding coverings of the hernia, a phlegmonous inflamma-

tion follows with perforation of the skin, and discharge of intestinal contents outwardly. Life may be saved with the spontaneous formation of an artificial anus. In very rare cases complete spontaneous cure may result. A case of this kind was in my care at the Roosevelt Hospital. The history is so unusual that I relate it briefly:

An old man, aged sixty-eight, was admitted to the hospital. Five days before, a left-sided scrotal hernia had become swollen, painful, and irreducible. Vomiting, prostration, abdominal distention, and other signs of intestinal obstruction followed. He remained in bed and sought no medical aid until brought to the hospital. His general condition was fairly good. Vomiting had ceased the day before, since when the swelling of the scrotum had greatly increased. The scrotum was much enlarged, reddened; the skin was perforated at several points; fecal matter was escaping freely from these openings. Under ether anesthesia, incisions in the scrotum opened a large fecal abscess with necrotic walls. The cavity contained a loop of gangrenous and perforated large intestine about fourteen inches in length. Identified as sigmoid flexure. The external ring appeared to be the point of constriction. The constriction was relieved by incision. A small amount of healthy gut pulled out; the gangrenous loop was cut away, and the ends of healthy gut were sewed by a few stitches to the borders of the ring and to each other, simply to prevent their retraction into the abdomen. Local and general conditions seemed to render an effort to unite and return the divided ends unwise. After the establishment of this artificial anus the general condition of the patient improved at once; slowly the sloughs separated from the scrotum, and it was found that by packing, the movements of the bowels could be partly controlled. After a number of weeks the whole raw surface became covered by healthy granulations, and diminished in size until only a cavity of moderate size existed opposite the external ring in the groin. The old man began to have an occasional natural movement from the bowels *per anum*; gradually the amount of fecal matter escaping through the groin diminished, and finally ceased. The wound healed and the patient left the hospital quite well and cured of his hernia.

Abscesses which form in the vicinity of the intestine may break outwardly, and into the intestine as well—i. e., an osteomyelitis of the sacrum or ileum—and result in intestinal fistula. While fistula may connect any portion of the intestine and the abdominal wall, certain situations are favorite sites—namely, the right iliac region, the inguinal regions, and the umbilicus. The occurrence of appendicular abscess, of tuberculosis, malignant disease, and actinomycosis of the cecum accounts for the frequent formation of intestinal fistulæ in the right iliac region. Strangulated inguinal hernia accounts for the formation of fistula in the groin. The umbilicus is a favorite site for several reasons. It is a weak place in the belly wall through which many intra-abdominal inflammations perforate. It is a common site of strangulated hernia. Omphalomesenteric fistula opens there. (See Omphalomesenteric Fistula). In cases of congenital umbilical hernia the division of the cord may create a fistula. As in the case of the stomach, we distinguish fistulæ in which the mucous membrane

of the gut is adherent to the skin, those in which a canal of some length exists between the skin and the gut lined by mucous membrane, rarely by skin, or most commonly by granulation tissue; further, those in which a cavity of some size exists communicating with the intestine and with the skin. These distinctions are important from a prognostic and therapeutic standpoint, since the first variety do not heal without operation. The others may, with exceptions to be noted. Intestinal fistulæ may be large or small. The entire intestinal contents may pass through the fistula, or only a part of it; in some cases so small a part that the recognition of intestinal contents in the discharge may be difficult. When the bowel evacuates itself entirely through the fistula, we speak of it as an artificial anus (anus præternaturalis). When only a part, as a fecal fistula. The quantity discharged through the fistula depends not only upon the size of the opening in the gut, but very largely upon the patency of the gut beyond the fistula. If the lower portion of the gut is entirely patent, a large fistula may discharge but little fecal matter. If not, a small opening may discharge much or all of the intestinal contents. The patency of the lower limb of the gut may depend upon a stricture or other cause of obstruction situated at a more or less distant point; in many instances it depends upon mechanical conditions affecting the intestine in the immediate vicinity of the fistula, developed as the result of the fistula, or existent at the time the fistula was formed. Inasmuch as the future history of these cases and the treatment depends largely upon these local conditions, it seems best to explain them here. When a fistulous canal of some length lined by granulation tissue connects a rather deeply placed coil of gut with the skin, the tendency is toward ultimate spontaneous healing; when, on the other hand, a coil of gut lies just beneath the abdominal wall and opens by a larger or smaller opening upon the skin, the conditions are different. The coil is acted on by three forces: Direct traction by the mesentery, peristalsis, and intra-abdominal pressure. No matter how flatly the coil of gut may have been applied to the abdominal wall at the time the fistula was formed, the mesentery tends to draw the intestine back into the abdomen; under favorable conditions spontaneous cure results. In other cases the area of gut occupied by the fistula is firmly attached to the abdominal wall; the pull of the mesentery will draw away both the afferent and efferent limbs of the intestinal loop, while their junction remains fixed. Thus very soon an angle or kink is formed in the loop whose apex is at the fistulous opening. The mesenteric attachment of the loop forms a bar or spur of mucous membrane which tends to diminish the size of the gut at this point, and therefore the freedom of the passage of intestinal contents through the natural channel, and to encourage its escape through the fistula. Peristalsis acts to force the contents of the afferent loop and its loosely attached mucosa toward the fistulous opening. Intra-abdominal pressure acts similarly. Prolapse of the mucous membrane of the afferent loop results. Peristalsis in the efferent loop tends to draw it away from the orifice. A continuance of these forces often results in complete prolapse of the mucous membrane of the afferent loop, and even of

its junction with the efferent loop; and in this manner a fistula of moderate size may be converted into an artificial anus. In the meantime the lower portion of the gut shrinks and undergoes partial atrophy from disuse; a permanent artificial anus is established, only to be relieved by operation, except in very rare cases.

The local and general results of fecal fistula and of artificial anus depend upon two factors—namely, the distance of the fistula from the stomach and the amount of intestinal contents escaping through the unnatural opening. An artificial anus in the colon, though unpleasant, does not in itself involve impairment of the general health. The same may be true of an opening at the lowest point of the ileum. A similar condition in the upper part of the small intestine leads to inevitable death from inanition. The nearer the stomach the opening lies and the larger the escape of intestinal contents from such an opening, the greater the likelihood of imperfect absorption and consequent innutrition. These facts render the surgeon extremely unwilling to leave an external opening in the small intestine, when it can by any means be avoided. When such an opening exists, the question of whether the patient is holding his own can be determined by weighing him from time to time, and the probable situation of the fistula may be inferred from the results. The diagnosis of the distance of an intestinal fistula from the stomach is therefore very important. The following data are useful: The contents of the small gut is fluid; that of the colon solid or semisolid. The contents of the duodenum and jejunum are bright yellow or yellowish-green in color from the presence of unchanged bile pigment; these pigments alter in color farther down, and become brown or dark brownish-green in the large intestine. Upon the skin the contents of the small intestine are irritating and even destructive. The skin becomes inflamed, red, and excoriated; digestion of the skin takes place. I have seen the skin of the abdomen destroyed over an area as large as a man's hand. These ulcerations are extremely painful. The higher up the lesion, the more intense the digestive action. In fistulæ from the large gut this digestive action is absent; eczema and dermatitis are usually present. The contents of the upper part of the small gut is odorless; lower down the characteristic fecal odor is gradually developed. Usually the recognition of a fecal fistula offers no difficulties. The escape of undigested or partly digested food—recognizable under the microscope as striped muscle fiber, starch granules, vegetable fiber, etc.—is easy. Gas quite commonly escapes from such fistulæ. When the fistula is very small and discharges only a little muco-pus it may be difficult. The odor of a discharge is not characteristic, since any pus focus near the intestine may be infected with colon bacilli and have a fecal odor. Sometimes by feeding a patient methylene blue or charcoal these substances may be recognized by their color when they appear in the fistula. The formation of a spur can be detected in case the fistula will not admit a finger by introducing two probes, one into either loop, and moving them about to feel the conformation of the gut between. When operating upon the intestines for the purpose of closing fistulæ, making

anastomoses between adjacent coils, excluding portions of intestine which are diseased and cannot be removed, creating a permanent artificial anus in the sigmoid when one end is to be closed and returned to the belly, it often becomes essential to determine which is the upper and which is the lower limb of the loop. If the case is one of an old artificial anus, or if a large part of the intestinal contents has escaped through the fistula, the differences between the two are striking. The lower loop is smaller, its mucous membrane paler, the intestine is empty and contracted. The upper loop is larger, contains fecal matter and gas. Prolapsed mucous membrane on the abdominal wall belongs usually to the upper loop. It is sometimes possible to tell by inspecting the prolapsed mucous membrane of a coil of gut whether it is large or small intestine. The mucosa of the small gut is velvety and dull; that of the large intestine smooth and glistening. These characters may be lost in mucous membrane long exposed on the surface of the abdomen. When, however, after opening the belly, the intestines are found matted together by adhesions, and if, as sometimes happens, several coils of gut communicate with the fistula, the question may not be so simple. It is sometimes possible by irritating the peritoneal surface of the gut to excite a wave of peristalsis which gives the correct direction of the fecal current. In difficult cases this has not in my experience been of much use. If practicable the surgeon may follow loop after loop with his fingers, until he is thus led to the duodeno-jejunal junction or to the cecum, as the case may be. If the coil of gut is free from adhesions, its direction may be determined by drawing it out of the abdomen and having it held straight, under a little tension, by an assistant. The surgeon slips his thumb and fingers down on either side of the gut in the direction of the mesenteric attachment, grasping the mesentery. Twists in the mesentery can thus be detected, and after they are unraveled, the position of the coil with reference to its mesenteric attachment serves to indicate the higher and lower portion of the coil respectively (Rand, Stimson, Monks). In the case of the large gut, error is likely to occur in the sigmoid flexure. In this case milk injected into the rectum will usually appear promptly at the orifice of the lower loop if no obstruction exists in the rectum, or the mesentery of the loop can be traced down to the rectum, care being taken to unravel existing twists. In spite of care and skill, mistakes do occur, and I have seen experienced and skillful surgeons close off the wrong end from the intestinal current more than once. The consequences of such an error are intestinal obstruction, which may or may not be relievable by a subsequent operation.

Internal Intestinal Fistulæ.—Internal intestinal fistulæ may form between different portions of the intestine, or between the intestine and other hollow organs, the gall-bladder and gall-ducts, the kidney, ureter and urinary bladder, the uterus, and very rarely the Fallopian tubes. The formation of the fistula may be due to inflammatory, ulcerative, or traumatic lesions of the intestine, or may originate in similar lesions of hollow organs not a part of the intestinal tract which perforate into the intestine. The causes of internal

fistulæ between different portions of the intestine are the same as the causes which produce external fistulæ, as already described. Usually fistulæ form between neighboring viscera, small intestine with small intestine or with colon. Kidney with colon or duodenum. Gall-bladder and gall-ducts with duodenum or hepatic flexure of the colon. Rectum, sigmoid flexure, lower coils of ileum, vermiform appendix, with bladder, uterus, vagina.

The symptoms produced by communications between adjacent coils of gut may not be recognizable. If the opening is large and a considerable portion of the alimentary tract is thrown out of the intestinal current, inanition may result. The condition may be suspected from the passage *per rectum* of only partly digested food too soon after eating to have traversed the entire canal. Biliary fistulæ between the gall-bladder and duodenum or colon are usually caused by the pressure and ulceration of large gall-stones and gradual perforation of the intestine. During their formation they may give no symptoms at all or no symptoms which can be differentiated from cholangitis, cholecystitis, localized peritonitis, etc. The establishment of a fistula between the gall-bladder or ducts and the duodenum need give no symptoms of itself. The formation of a fistula from the biliary passages into the colon will lead to the imperfect digestion of fats. The formation of fistulæ between the intestine and the female genital tract is very frequent. The causes are labor, especially instrumental deliveries, versions, etc.; surgical operations upon the uterus, curettage, etc.; accidental injuries; ulcerations from cancer of the uterus. Very rarely does the process arise in the intestine itself, and is then commonly due to tuberculosis. The diagnosis depends upon recognizing the escape of intestinal contents from the vagina. The character and amount of the discharge permit a judgment to be formed of the position of the fistulous opening in the gut. (See External Fistulæ.) Examination of the vagina by sight and touch permits the size and situation of the fistula to be recognized. If the fistula communicates with the uterus, the discharge will escape through the cervix. Fistulæ between the intestine and the urinary tract occur between the gut and the kidney or its pelvis, between the ureter and the colon or rectum as the result of the intentional acts of surgeons, and between various parts of the gut and the urinary bladder. Fistulæ between the kidney or its pelvis and the gut are rare. They occur from ulcerative processes set up by kidney stones or from destructive inflammatory processes of other origins in the kidney, acute abscess, pyonephrosis, and tuberculosis of the kidney. They open much more commonly into the colon than into the duodenum. Urine may pass into the intestine or intestinal contents into the urinary tract, or both. The diagnosis has occasionally been confirmed by the formation of an external fistula as well. When urine passes into the intestine the diagnosis is to be made from the passage of urine or of urinary ingredients in considerable quantities *per rectum*. Urea, uric acid, etc. If the escape of urine into the gut is small, or if the fistula opens into the duodenum, reabsorption of the urine by the intestine will render the findings of little value, since urinary ingredients may appear in the feces

in small quantities when no fistula exists. In the few cases of duodenal fistula which have been verified, urine has sometimes passed into the stomach and been vomited, as have renal calculi. When intestinal contents enter the urinary tract, the consequences are always serious; infection of the urinary apparatus is inevitable; at first, a descending infection; later, in many cases, an ascending infection also. Thus cystitis, followed by pyelitis, pyelonephritis, etc., often follows the constant escape of intestinal contents into the bladder, and it has been found that implantation of the ureters into the sigmoid flexure of the colon is regularly followed by pyelitis and fatal infection of the kidney. In order to recognize the condition positively, it is necessary to find actual intestinal contents in the urine, particles of meat fiber, starch granules, etc. The mere presence of a fecal odor or of saprophytic bacteria in the urine establishes nothing. Even the presence of gas in the bladder is not conclusive, since gasogenic bacteria may reach the bladder from other sources, or the fermentation of diabetic urine may produce the same condition. The diagnosis might be confirmed by giving the patient methylene blue by the mouth; this produces a blue coloration of the urine. If the feces were stained blue, it would indicate the passage of urine into the intestine. By giving the patient charcoal by the mouth, its presence in the urine would indicate the passage of intestinal contents into the urinary passages. By far the largest number of intestinal fistulæ into the urinary tract are connected with the bladder. In about half the cases the fistula communicates with the rectum; in a considerable number with the sigmoid flexure; less often with the lower coils of ileum; rarely with the appendix or the cecum. The causes are very various. Trauma, tuberculosis, cancer of the intestine, abscesses connected with the intestine which rupture into the bladder (a perforated appendix, for example), inflammatory processes originating in the prostate, pericystitis, etc. The symptoms are a sudden or gradual development of cystitis; the escape of gas with the urine; further, the identification of intestinal contents in quantity or under the microscope. If the communication is with the sigmoid or rectum much or nearly all the urine may pass *per rectum*. (See Genito-urinary Organs.)

Diagnosis of the Complications following Abdominal Operations.—The complications occurring after operations upon the interior of the belly may, for purposes of description, be grouped under (1) shock, (2) hemorrhage, (3) infection of the external wound, (4) peritonitis, (5) intestinal obstruction, (6) pneumonia, (7) bleeding from the alimentary canal, (8) thrombosis and embolism. These constitute the most frequent conditions to be met with and recognized; others may, of course, appear under special circumstances in infinite variety.

Shock.—Shock after extensive and prolonged operations upon the belly, or after slight abdominal operations upon patients who are already weakened by peritonitis, hemorrhage, starvation, or other cause, may be so severe that the patient either dies upon the operating table or does not regain consciousness and dies in a few hours in a state of collapse. The symptoms do not differ

from those already mentioned under "shock." The heart beats more and more rapidly and feebly. Respiration is shallow and slow or irregular. The extremities and the forehead are cold. The cutaneous and mucous surfaces pale. The body is bathed in a clammy sweat. When death is very near, the pupils of the eyes dilate. If the patient regains consciousness at all, cerebration is sluggish and imperfect. In some cases, under suitable treatment, the patient rallies a little, but very soon fails to respond to stimulation, and dies in a few hours. Some observers describe a condition under the title "Delayed Shock" such that the patient appears to bear the operation well or to rally from the shock only again to sink and die after twenty-four, thirty-six, or forty-eight hours. I believe that in most of these cases the death has been due to undiscovered bleeding or to a very intense acute sepsis. Be that as it may, if at the end of the operation the pulse has been of fair quality and not above 100 to 110 beats per minute, or if, though shocked, the patient has responded well to stimulation and has maintained a pulse of fair quality and of a falling rather than a rising frequency for twelve to twenty-four hours, a progressive change for the worse, a failing heart as indicated by an increasing pulse rate, waxy pallor, restlessness, great thirst, marked abdominal pain and distention, repeated vomiting, coming on after an interval of several hours or a day of fairly satisfactory progress, should always lead the surgeon to suspect intra-abdominal bleeding, peritonitis, or some serious complication other than mere shock.

Intra-abdominal bleeding produces the symptoms described under Injuries of the Abdomen. In some cases the surgeon may have some clew to the source of hemorrhage from the character of his operation, the position of his ligatures, etc. If the symptoms are marked and progressive, reopening of the belly and control of the bleeding vessel is the best and only rational treatment. It is perhaps needless to state that saline infusions into veins should not be given until the bleeding is controlled. If a donor is obtainable, direct transfusion may be tried.

Hemorrhage from the Alimentary Canal.—Vomiting of blood or passage of blood *per rectum* may of course follow operative measures upon the stomach and intestine. Such bleeding may also take place from causes not entirely clear—notably after operations involving resection of the omentum and mesentery, and strangulated hernia and obstruction of the gut from other causes. In some of these cases more or less extensive thrombosis of the mesenteric veins has been discovered at autopsy; in other cases, anemic necrosis of the mucous membrane of the gut has been observed (von Eiselberg, Kocher). Vomited blood exposed to gastric digestion resembles coffee grounds. Blood retained in the bowel for any length of time and passed *per rectum* resembles tar.

In conjunction with the diagnosis of wound infection and peritonitis, some general remarks may not be out of place. Vomiting after abdominal operations is common as the result of ether anesthesia. In many cases it is confined to

the first few hours, and ceases soon after the patient regains consciousness. In others, vomiting at intervals continues for forty-eight hours, seldom much longer unless some complication is present. Such may be local or diffuse peritonitis, intestinal obstruction from adhesions, paralysis of the gut, atonic and temporary or inflammatory and permanent. After operations upon the stomach, bleeding into the stomach will produce vomiting. After gastroenterostomy, a vicious circle of the intestinal current may cause continued and fatal emesis. A preëxistent chronic gastritis, a nephritis, and other nonsurgical affections will have to be considered in certain cases. A continuance of vomiting after two or three days, uncontrolled by complete rest of the stomach and by gastric lavage, arouses the anxiety of the surgeon and demands a careful search for its causation. In favorable cases patients are able to retain small doses of suitable food after twenty-four hours.

Symptoms Referable to the Intestine.—A certain amount of atonic paralysis of the gut follows operations involving much handling of intestinal coils, traction upon the mesentery, long exposure to the air, suture and resection of the intestine, evisceration, separation of extensive adhesions, etc. There results more or less distention of the bowel with gas, moderate tympanites in some cases, and abdominal pain of bearable intensity, lasting from twenty-four to forty-eight hours. Partly owing to atony of the bowel, partly to inability to use the abdominal muscles on account of pain, patients do not evacuate flatus *per rectum*. After twenty-four to thirty-six hours this power is usually regained, and gas is usually expelled naturally, or through a stomach-tube left in the rectum. Inability to move the bowels may last much longer. Many surgeons are accustomed on the third day or earlier to administer calomel in divided doses (gr. $\frac{1}{2}$–$\frac{1}{4}$) every hour for six to eight hours, followed by enemata; if no movement follows, a saline laxative is given by the mouth. Such procedures are followed by success in most cases unless something is going wrong. Still, as long as gas passes *per rectum* and the patient's pulse remains below a hundred and of good quality, in the absence of marked abdominal pain and distention and of vomiting, the fact that the bowels do not move for four or five days is not a cause for serious anxiety.

Retention of Urine.—Retention of urine is common during the first days after an operation on the belly. It occurs both in men and women, and among the latter notably after operations on the uterus, ovaries, and tubes. It depends to a great extent upon the unaccustomed necessity of performing the act while lying upon the back, and is recovered from in a few days. After a serious operation, but little urine may be formed for the first twelve hours. If no urine has been passed by the morning following the operation, and no desire to urinate has been expressed, the catheter should be passed at eight-hour intervals or less until the bladder can be emptied voluntarily.

Temperature after Abdominal Operations.—A moderate rise of temperature during the first thirty-six hours is common and not alarming. Its height and duration will depend upon the character of the operation, whether

clean or done for an inflammatory condition, upon the amount of intraperitoneal oozing, the extent of raw surface left uncovered by peritoneum, the ability of the surgeon to remove septic materials completely. A rise of temperature developed after a number of days, or a temperature which remains elevated when local conditions as far as known do not appear to account for it, is a cause of anxiety. Very often a patient who has a moderate rise of temperature for several days will cease to have fever at once when the bowels have been thoroughly moved. A most important fact to bear in mind is that very serious abdominal conditions may exist without a corresponding rise of temperature, and the presence or absence of fever is not a reliable guide in estimating the gravity or progress of the given case. (See Peritonitis.)

The Pulse.—An increase in the pulse-rate is the rule after abdominal operations. The rapidity will depend upon the gravity of the procedure, the amount of shock or bleeding, the presence or absence of sepsis at the time of the operation. After the immediate effects of the operation have passed off, a pulse-rate of 100 is not a cause for anxiety. A pulse which remains at 120 and shows an upward tendency is ground for serious consideration in the absence of pneumonia or some factor to account for it; peritonitis, either localized or spreading, is the most probable explanation. Sepsis, a degenerated heart muscle, with feeble or imperfect resistance and absence of an efficient reparative process, are also to be thought of. When the pulse-rate steadily creeps up from 120 to 140 and 150, becomes thready, when the extremities become cold and cyanotic, the forehead bathed in a clammy sweat, the features pinched and drawn, the lips blue, the eyes dull, the patient is dying.

Infection of the External Wound.—Infection of operative wounds of the abdominal wall sometimes occurs after operations for septic intra-abdominal conditions. In these cases the superficial wound will probably have been left entirely open or partly open and drained. Some infection will be looked for, or at least will create no surprise; its presence will be evident on inspection. Infection occasionally follows clean operations; the wound will have been sutured. No drains, or small rubber-tissue drains only, will have been introduced at the wound angles, and removed at the end of twenty-four hours. A somewhat tardy and not very virulent infection of such wounds sometimes develops during the week following the operation. The infection very rarely invades the peritoneum, but usually forms an abscess in the subcutaneous wound space, less commonly in the muscular layers.

In these cases the following signs and symptoms lead the surgeon to explore the abdominal wound. The immediate effects of the operation have passed off, the bowels have moved, the patient does not vomit. He has no intra-abdominal pain. He has a vague sense of discomfort. His countenance is not cheerful. His appetite does not return. His tongue remains coated. He does not sleep well. He has a daily rise of temperature—99.5° F. in the morning, 100.5° to 101.5° F. in the evening. His pulse-rate is increased to 95 to 105 beats per minute. Locally, he may complain of moderate discomfort or moderate pain

in the abdominal wound. Upon inspecting the wound the suture line may be reddened or appear perfect. There may be a visible fullness in the vicinity of the wound. If the wound edges are reddened, a drop or two of pus may appear through the stitch holes in the skin. Upon palpation tenderness will be complained of when gentle pressure is made on the wound edges. Fluctuation will not usually be appreciated. Upon opening the wound several conditions may be found. A few drams of blood-stained pus may be evacuated; the separated wound surfaces will show but slight signs of infection; there may be small areas of fat necrosis here and there, notably at the sites of ligatures. In other cases merely a broken-down blood clot will be evacuated. In still others a quantity of thin, brownish-yellow fluid containing many fat drops will escape (fat necrosis). Signs of distinct infection may be absent. In more severe cases the subcutaneous tissues will appear superficially necrotic and infiltrated. If the infection is in the intermuscular planes, removal of muscle sutures will evacuate a greater or smaller quantity of pus. Under suitable treatment (relief of tension by removing sutures, free drainage) such infections subside rapidly. The patient's general condition improves at once, fever disappears, etc. The wound becomes clean in a few days, and may be sutured or strapped.

Peritonitis.—Following abdominal operations both for septic and clean conditions, peritonitis is the most justly dreaded of complications. It may simply be a continuance of the original process for which the operation was done, or may arise from errors in surgical technic not always to be guarded against even by the most careful surgeons. It is most apt to occur in those cases whose powers of resistance have been greatly diminished by profound anemia, by chronic alcoholism, malignant disease, and other depressing conditions. It is produced by inadequate removal or drainage of septic foci at the time of operation, and, as stated, in clean cases by errors in aseptic technic. In the given case peritonitis may assume any of the forms already described under Peritonitis from infection with pyogenic bacteria. Clinically it is most important to distinguish between a diffuse purulent peritonitis without limiting adhesions and a localized process with the formation of one or more definite loculi of pus in the abdomen. The cases of the first class, if post-operative, are almost invariably fatal. Those of the second may often be saved by prompt reopening of the belly.

The symptoms and signs of the two types do not materially differ from those already described under Peritonitis. The characters of the diffuse form may be briefly recapitulated. If peritonitis existed at the time of operation, the symptoms and signs will continue and grow worse. If not, it may be forty-eight hours or more after the operation before definite symptoms appear. They will be abdominal pain, rigidity and distention, restlessness, anxiety, a coated tongue, a dry skin, repeated vomiting, at first of bile-stained fluid, later of intestinal contents of a dirty brown color and fecal odor. The vomiting, at first violent, ceases to be so later, when brown fluid pours out of the patient's

mouth in quantity without apparent effort. There is absolute constipation. A progressively rapid heart, a pulse growing steadily more feeble, compressible, and rapid until the end. An elevation of temperature may be absent in the worst cases. In others fever of very variable degrees of intensity will be present, and may rise to 106° to 107° F. a few hours before death. Generally speaking, a marked rise of temperature on the second or third day, which continues and becomes of septic type, is strongly suggestive of peritonitis unless some other complication is present to explain it. The external wound may be normal in appearance. There may be redness of the skin and pus in the wound. The wound edges from the skin to the peritoneum may be gangrenous. It very rarely happens that reopening the belly in cases of diffuse septic peritonitis following operation is successful in saving life. One of the worst signs in these cases is total paralysis of the gut, appreciable on opening the belly.

Localized Peritonitis.—Localized peritonitis with the formation of a walled-off abscess, or of the progressive fibrino-purulent type, may follow any surgical operation upon the belly. It may be due to the same causes as the diffuse form. In many cases it follows imperfect removal or drainage of septic foci, or the giving away of sutures and slow leakage of septic products from some sutured viscus (gall-bladder, stomach, intestine, urinary bladder, appendical stump), sometimes the breaking down of a previously infected retroperitoneal gland or portion of infected omentum. The signs and symptoms are those described under Peritonitis. The continued vomiting, fecal vomiting, intense prostration, general rigidity and distention, absolute constipation, and rapidly failing heart of diffuse peritonitis are wanting. The local signs of pain, rigidity, and tenderness are present, together with the general symptoms of sepsis of a more or less acute type. The patient is ill, and becomes more ill from day to day. There is usually fever, moderate or high. The pulse-rate is increased. Leucocytosis with relative increase of polynuclear leucocytes is present in nearly all cases. These data, together with the local signs and symptoms, must furnish the operative indications in the individual case.

Pneumonia.—Pneumonia, usually of the lobular type, is not an uncommon sequence of operations upon the belly. It is probably more frequent here than after other operations. In some instances it is attributable to the anesthetic or to the aspiration of septic material during anesthesia. In others it is to be regarded as a part of a general septic process; in these cases, when death occurs, the pneumonia is hardly to be regarded as more than a contributory causative factor. For the signs and symptoms of broncho-pneumonia the reader is referred to works on General Medicine. Pneumonia following surgical operations is recovered from in a large percentage of cases. In a good many instances it is difficult to say at first whether the process is a pneumonia or an intense congestion of the lungs with edema and a more or less acute bronchitis.

Thrombosis and Embolism.—Thrombosis of the external iliac, less often of the common iliac veins is a complication of operations upon the belly in

a pretty large number of cases—perhaps in one per cent of abdominal operations. I have seen it after appendicitis more often than after other operations. I have rarely seen it follow operations for acute appendicitis with abscess, peritonitis, or other acute lesion. It has usually followed clean interval cases during convalescence, when the general condition of the patient was good and the wound healed by primary union. For reasons not at all clear, it occurs upon the left side of the body in all but a very small percentage of the cases. It is rare before the end of the first week, and may occur as late as a month after operation. In a recent case, phlebitis and thrombosis of the left common iliac vein occurred six weeks after cholecystectomy for pressure necrosis of the gall-bladder due to impaction of a very large stone in the cystic duct; the case was complicated by empyema in the right pleura. The phlebitis and thrombosis antedated the empyema by several weeks. The patient recovered. The signs and symptoms are rapid swelling and edema of the entire lower extremity, accompanied by moderate or severe pain and discomfort, and usually a moderate rise of temperature and an accelerated pulse. If the common iliac vein is thrombosed in men the scrotum will also become swollen and edematous. The femoral vein may be palpated as a tender, hard cord in Scarpa's triangle, as large as a man's thumb. Tenderness and sometimes a sense of resistance can usually be traced above Poupart's ligament into the pelvis. Complete though slow recovery is the rule. A few of these cases are preceded or followed by pulmonary embolism. In some cases there are no symptoms except sudden, instant death. In others the patient is suddenly seized with intense precordial distress and dyspnea. Progressive heart-failure may end life in minutes or hours. A few cases recover. (For the diagnosis of "Septic Pylephlebiti of the Portal Vein," see Diseases of the Liver.)

Intestinal Obstruction following Abdominal Operations.—Intestinal obstruction may follow operations upon the belly at any time during convalescence or after long delay and a prolonged period of health. The first variety alone will be discussed in this section. A common cause is the formation of a sharp kink in a coil of gut maintained in position by the rapid adhesion of adjacent peritoneal surfaces, and favored by intestinal atony, peritoneal irritation, and peritonitis. *It is certain that intraperitoneal gauze packings introduced as drains may favor, and actually produce, this form of obstruction.* Twists and kinks may be produced by the surgeon when handling or reducing prolapsed coils into the abdomen. Volvulus may form spontaneously. Slits in the mesentery or omentum may lead to an internal hernia, as may adhesion between adjacent coils of gut with the formation of an orifice or pocket into which other coils find their way and become strangulated. *Old adhesions and bands may be responsible for the condition as well as new.* Sometimes obstruction may be caused directly by the operation, as when the transverse colon is directly compressed after the operation of anterior gastroenterostomy, or as when an intestinal anastomosis produces an orifice or pocket into which other coils enter. Intestinal paralysis due to peritonitis or to handling of the gut,

traction on its mesentery, etc., as already mentioned, may cause not only temporary but permanent paralysis and obstructive symptoms. (For further details of causation, see Intestinal Obstruction.) In the given case obstruction must be thought of when vomiting continues after forty-eight hours and grows more frequent in spite of rest for the stomach by giving no food by the mouth. When no gas passes *per rectum*, when abdominal distention is progressive, when in spite of enemata and gastric lavage the vomiting becomes bile-stained and finally fecal and the bowels cannot be moved, obstruction certainly is present, either mechanical or paralytic. Together with these symptoms there will be abdominal pain and tenderness. The presence of fever suggests peritonitis rather than mechanical obstruction. (See also Peritonitis.) If the obstructive symptoms occur during the early days after operation, the surgeon may sometimes be at a loss to distinguish the condition from peritonitis, or from the not infrequent cases in which both conditions exist. More lives will be saved by reopening the belly early than by delay. If peritonitis and paralysis of the gut are found, the patient will die, but he will have been given the best possible chance. If mechanical obstruction exists, relief is possible by early operation in many cases. When the obstructive symptoms develop after convalescence appears to be established at an interval of a week, a fortnight, or more, the likelihood of peritonitis may be regarded as remote. Operation should be done as soon as the diagnosis can be made, and before the symptoms become urgent. A few hours' delay may find the patient in a condition of collapse such that no operation is possible.

The two following brief history abstracts illustrate the good results of immediate interference and the fatal results of delay: I operated upon a young woman for acute appendicitis, with perforation and a localized abscess, the wound being left partly open and drained. Normal convalescence up to the fourteenth day. On that day acute abdominal pain, frequently repeated and uncontrollable vomiting of bile-stained fluid. Progressive acceleration of pulse-rate and slight tympanites. Operation by enlarging the former wound six hours after the first symptoms of obstruction appeared, disclosed a coil of ileum twelve inches from the cecum, sharply kinked and held by recent adhesions. The intestine above the kink dilated, below collapsed. Adhesions easily separated with the fingers. Gas seen to pass freely by the former obstruction. Wound partly closed. No further obstructive symptoms. Normal recovery.

The second case was a little boy aged ten. Acute appendicitis; operation. Perforated appendix. Progressive fibrino-purulent peritonitis not far advanced. Appendix removed; infected areas of peritoneum washed. Gauze drainage. Rapid wound healing. Normal convalescence up to the fifteenth day. On the night of that day sudden violent abdominal pain and repeated, uncontrollable vomiting. Acceleration of pulse-rate and prostration. For reasons which need not be specified, I was not called until the following morning, and was unable to reach the patient until noon. At this time the child was in collapse, nearly pulseless. Temperature subnormal. Extremities cold; cya-

nosis of the face and fingers. Fecal vomiting every few minutes. Abdomen a little distended, not markedly tender. Condition of patient such that no operation could have been borne. Active stimulation and high enemata of no avail. Patient became unconscious at 1.30 P.M. and died at 2 P.M.

The following case history illustrates intestinal obstruction from ancient bands and adhesions: The obstructive symptoms came on rather gradually, and the obstruction did not become complete for many days. For reasons not entirely clear to myself at the present time, I failed to appreciate the gravity of the situation until the patient was very ill, and my bad judgment in this case nearly cost the patient his life. Since this man left the hospital I have seen him at intervals; he remains in good health.

Acute Intestinal Obstruction from Adhesion Bands following Appendectomy.—A man, aged thirty years, who entered the Roosevelt Hospital on January 8, 1900, with the following history: Fifteen years before he had a severe attack of illness, which seems to have been due to an inflammation of the vermiform appendix. He remained well after recovery from this attack until five months ago, when he had a typical attack of appendicitis, severe in character, confining him to his bed for many days and terminating in an imperfect recovery, the region of the appendix having remained tender upon pressure ever since. Three weeks ago he had another severe attack, accompanied by the formation of a tumor in the right iliac fossa. Since then he has lost strength and flesh, and has constantly suffered from considerable discomfort, referred to the region of the appendix.

Upon admission to the hospital his evening temperature was 100° F.; pulse, 84. There was tenderness on pressure and a slight sense of resistance to be felt over the appendix. He remained under observation until January 20th, during which time he had a slight evening rise of temperature. The local conditions remained about the same. Upon January 20th the abdomen was opened by the intermuscular incision of McBurney. The cecum was found to be firmly adherent upon its outer and posterior surfaces to the peritoneum covering the iliac fossa. After a rather tedious dissection, a small abscess was opened, which contained about half a dram of pus. This abscess was found to communicate, on the one hand, with the open end of an appendix about an inch in length, a considerable part of the organ having apparently been destroyed, and on the other with a small opening in the wall of the cecum at a point about an inch and a half distant from and below the base of the appendix. The cavity of the abscess was wiped out and the granulation tissue forming its walls was removed with a curette. The hole in the gut was closed with several mattress stitches; the appendix was amputated at its base, surrounded by a purse-string suture and inverted in the intestine.

The necessary manipulations of the cecum were prolonged and severe. A small drainage wick was placed in contact with the sutured portion of the gut and the cavity of the abscess, and led out through the abdominal wound. The remainder of the wound was closed by sutures. The patient bore the operation

well; his temperature rose after forty-eight hours to 101.8° F. He vomited several times on the day following the operation, and, although on the next day his temperature fell to 99° F., and remained at that point for the following five days, his stomach continued irritable. His bowels moved freely upon the third day; the vomiting was greatly diminished in frequency by washing the stomach. The wound remained entirely clean except for the discharge of a small amount of pus along the sinus created by the drainage wick. At the end of a week his condition was entirely satisfactory, but on the eighth day the vomiting recurred. He had had one or more movements daily from the bowels up to this time.

Although the wound remained clean, his temperature rose on the tenth day to 101.8° F. During the ninth and tenth days following the operation he began to vomit more often, and to complain of pain in the stomach after taking food; his bowels became difficult to move, and upon the tenth day the vomited material changed in character, became of a dark-brown color, and had a disagreeable odor. He also suffered from severe abdominal pains, and his pulse showed signs of failing strength. Upon the eleventh day he did not vomit; his bowels moved once; but upon the following day the vomiting and abdominal pains recurred. Upon the fourteenth day this condition was more serious, the vomiting and pain continued, and the vomited material was of a decided fecal character. Numerous high enemata brought away only small amounts of fluid feces mixed with mucus and blood. He began to grow very weak and to suffer from abdominal distention, with severe abdominal pains. His pulse became very rapid and feeble in spite of powerful stimulations. On the morning of the fifteenth day the signs of acute intestinal obstruction were unmistakable. His eyes were sunken, his extremities cold, his abdomen distended; he vomited frequently, and the vomited materials were distinctly stercoraceous. The bowels could not be made to move. Accordingly, upon the fifteenth day he was etherized, and a median abdominal incision was made, with its center opposite the umbilicus; the peritoneum was clean, but coils of distended and congested small intestine presented in the wound. These were pushed toward the left, when other coils of small intestine were seen in a collapsed state, which, being followed, led to the right side of the abdomen in the region of the ascending colon. The ascending colon and two coils of small intestine were found agglutinated into a solid mass. The coils above this mass were distended, those below were collapsed. Upon further examination a broad, fibrous band was seen passing from the ascending colon toward the left; behind it was the outermost coil of small intestine. Its caliber was completely shut off by the pressure of this band. The inner coil did not appear to be completely obstructed, and the band extended across its front to be attached upon the farther side to its mesentery. The band was divided and, as far as possible, cut away with the scissors, when the collapsed coils immediately filled from above. The two coils of small intestine, however, were found firmly adherent to one another over an area represented by nearly half their surfaces for a distance of about

three inches. They were separated with difficulty. The bleeding during the manipulations was considerable, and the patient's condition indicating an alarming collapse, he received a hot saline intravenous infusion of 2,000 c.c.

Temporary pressure was applied to these bleeding surfaces by means of gauze pads, and the pelvis was explored for other possible causes of obstruction. Numerous bands and broad adhesions were also found between the coils of small intestines situated in the pelvis; although not apparently causing trouble, the bands were cut away. The broad adhesions were let alone. The bleeding here was checked by temporary packing. The coils of small intestines which had been obstructed were moved as far as possible toward the left side of the abdomen. The site of the operation was thoroughly washed with hot salt solution and wiped dry.

The abdominal wound was closed with sutures except at its lower part, where an opening was left for two strands of gauze leading from the bottom of the pelvis and from the inner side of the ascending colon, where it had been adherent to the small intestines. Although very weak, the patient responded to the most active stimulation, and upon the following day a small movement from the bowels occurred as the result of an enema. His temperature rose to 102.4° F. at the end of forty-eight hours. He was fed chiefly *per rectum* for two days, after which, the vomiting having subsided, he was given liquid nourishment by the mouth. At the end of forty-eight hours an abundant movement of the bowels occurred, after which movements occurred regularly without trouble. The abdominal wound remained clean, and the packing was removed at the end of the fifth day and replaced by a much smaller quantity. His abdominal wound healed for the most part *per primam*, and he has now almost a linear scar. His convalescence was slow but uninterrupted. I saw him seven years later. He had remained quite well.

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